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PRODUCT ENGINEERING

McGRAW-HI WEEKLY FOR DESIGN ENGINEERS • MARCH 13, 1961

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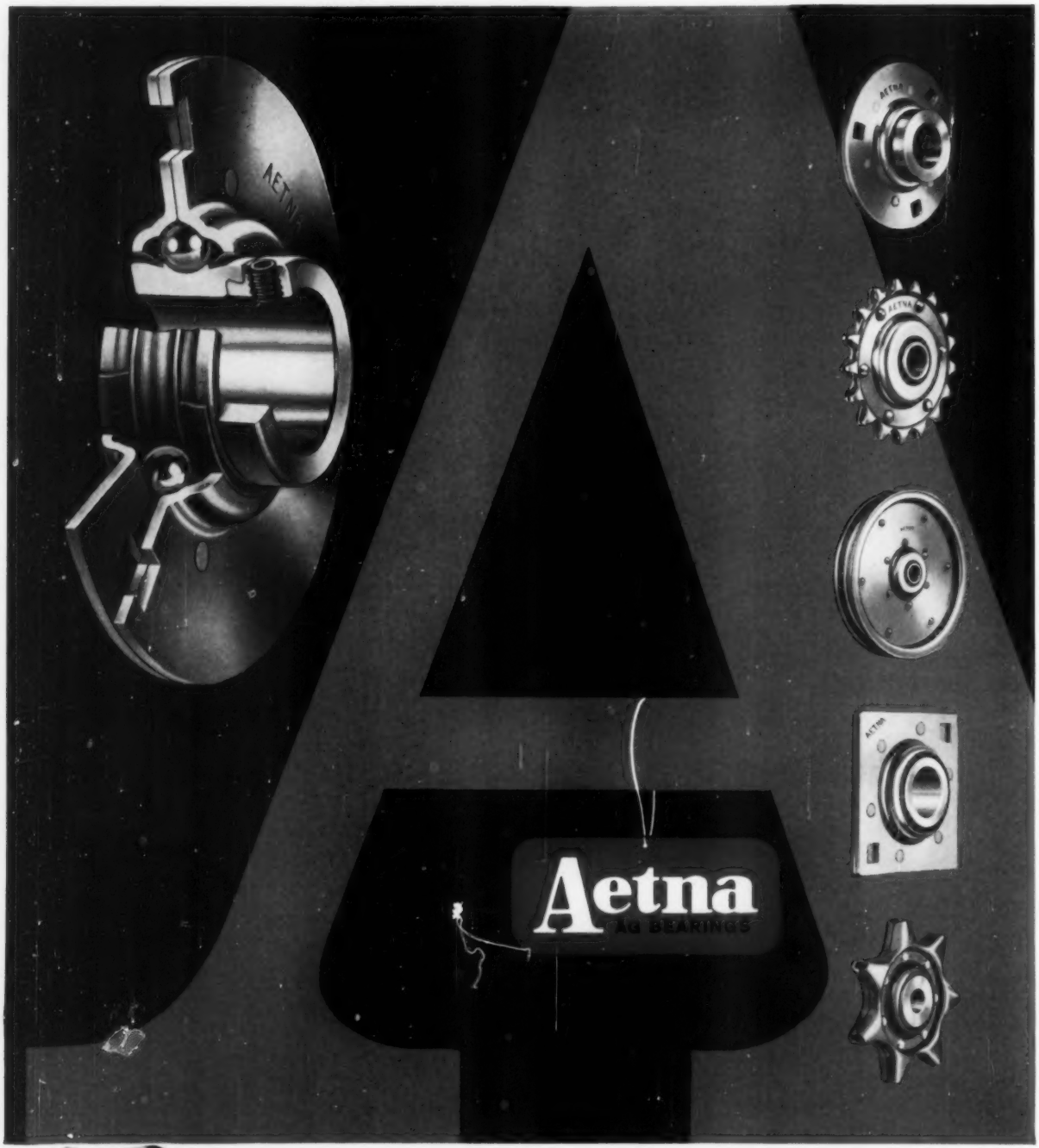

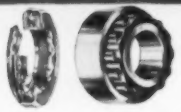

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McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

March 13, 1961 Vol. 32, No. 11

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Mach 5...Mach 10...and Beyond

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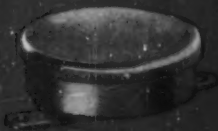

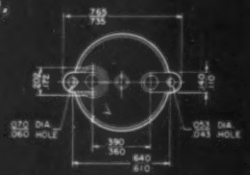

6°F is difference between maximum open and minimum close.

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INTERESTING TO NOTE

On our cover—two new International Harvester tractors, together with the groups responsible for the design of each machine. The picture was taken at the company's Farm Equipment Research & Engineering Center, Hinsdale, Ill, between snow storms during the Christmas holidays (which accounts for the building decorations and overcoats). Shown are the two extremes of the tractor line—

Left to right: Richard G. Hennessey, power train design; P. Lawrence Mikeska, chassis design; William D. Syrett, styling and visual design; David L. Stevenson, test and development; Harold E. Brown, project engineer, chassis; Horst Steinhagen, transmission design; R. Duane Cope, body and general design; Joseph Yocum, construction and field test; William J. Akins, project engineer; Ray Melchin, construction and field test; Palmer Hagen, general design.

the biggest tractor IH has ever made, the 300 hp 4WD-3, and the smallest, the 7-hp Cub Cadet. Design story on page 76.

Without question, the most important development in agriculture in modern times was the transition to power farming. Since World War I, when the "age of tractor power" really began, and particularly since the coming of all-purpose and rubber-tired tractors, nearly every phase of farm progress has revolved around tractor power.

Actually, the word "tractor" meant nothing to the public until the season of 1906-07, when it appeared in a manufacturer's advertising as a shorter way to say "gasoline traction engine." Tractor manufacturing as a large-scale industry is considered to have had its beginning in 1906, which saw 11 companies in the business. Their output the following year was 600 machines. Two years later, 31 manufacturers were producing tractors. Their combined production—2000 units.

It took courage for a farmer to invest his money in one of those early models. He risked the taunts of his neighbors when it wouldn't start and he risked his arm every time he cranked it, particularly before the use of an impulse coupling for the magneto. By 1918, tractors were "laid out on drawing boards" and "engineered" for mass production. As tractors climbed in prominence "ole dobbin" began to decline. In 1910, American farmers owned 1000 tractors and 24.2 million horses. By 1959, the figures were 4.8 million tractors and 3 million horses.

Crutch for the Eyes

Among many of the "miracles" that Marco Polo witnessed during his trip to China in the 13th century were people peering through "lenses" to read small print. But

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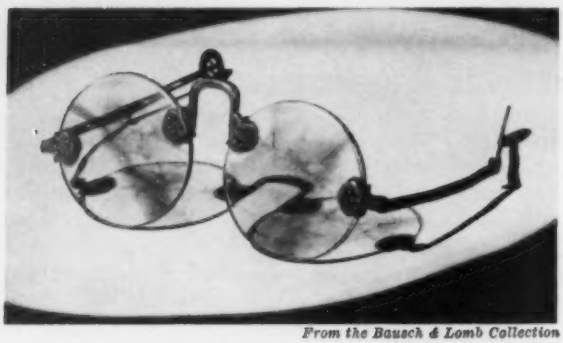
he was rather late. As far back as 2883 BC, Chinese had been using lenses made of rock crystal, quartz or amethyst to observe the stars. Even Confucius, in 500 BC, is said to have had a pair of eyeglasses. It is believed, however, that the early Chinese knew little about optical laws, believing that the glasses simply possessed certain mysterious medicinal properties. Chinese glasses were oval in shape rather than round, and were held in place by frames of papier-mache or horn.



From the Bausch & Lomb Collection

Chinese spectacles with quartz lenses, circa 1500 AD. Metal frames and nosepiece are fastened securely to the lenses with hinge clamps.

Lenses were known in ancient Greece and Rome; but these were used to set fire to enemy ships or to melt writings from wax tablets (acting like a sort of early eraser). Pliny records that physicians also used the "burning glasses" as cauteries, and, around 50 AD, Seneca observed that writing became large and distinct when seen through a water-filled glass. Little, however, was done to apply the "burning glass" to aid the poor-of-sight. It was not until 1276 that Roger Bacon referred to certain lenses as "useful to those who are old and have weak sight."

Eyeglasses were made by craftsmen who understood basic optical laws, and in the 15th century, the Guild of Master Spectacle Makers was established in Nurnberg. This elevated the spectacle maker to the level of a craftsman, like tailor or mason. In 1629, England's Worship Company of Spectacle Makers was chartered and still is in existence. These early spectacle manufacturers could design simple optical systems (a review of fundamental optics for engineers is on page 65), and by the end of the century, opticians were skilled enough to correct a wide range of eye defects. Benedict A Leerburger Jr

SIDELIGHT

Man's conquest of machine is commonplace; machine's conquest of man is news, but when animals get into the act it makes you wonder. Last month an AP dispatch from England reported that a hare had lured 11 rabbit hounds onto a railroad track, then proceeded to hop over an electric rail. The dogs decided to use the rail as a step and electrocuted themselves. This itself might have been considered an accident had a fox not lured 16 foxhounds to the same electric rail a week previously—with the same disastrous results. As for the fox and hare, they're still roaming about the English countryside.

NEXT WEEK IN PRODUCT ENGINEERING

. . . **How to Choose a Dynamic Seal**

A complete review of all the types and an analysis of each in terms of basic selection factors, materials and design recommendations.

. . . **How to Specify Dynamic Seals**

A standard form coordinates the work of customer and manufacturer, and simplifies even the most complicated seal problem.

. . . **SCR's vs Thyratrons**

An evaluation of the controversial questions raised at New York's recent AIEE convention.

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For dry bearing surfaces these oriented glass fibers make the Teflon strong, and the solid lubricant keeps it slippery.

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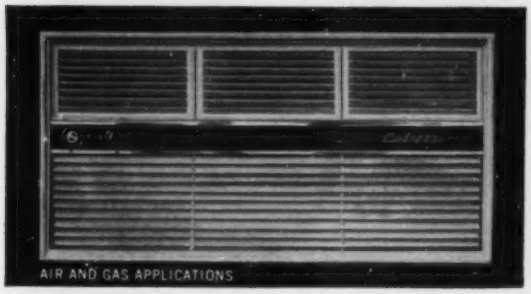
Here's how collared, extruded or dimpled flanges solve many problems commonly found when working with sheetmetal.

An example of Avisco Rayons in Industry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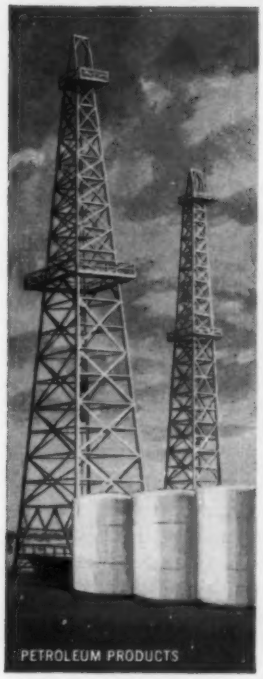
CREAMS AND LOTIONS

INDUSTRIAL APPLICATIONS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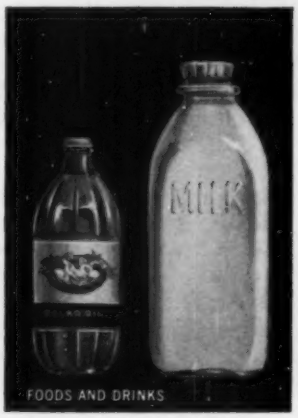
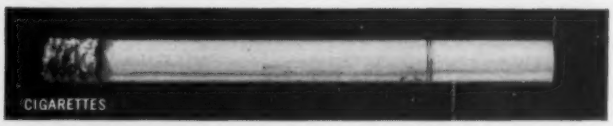


FOODS AND DRINKS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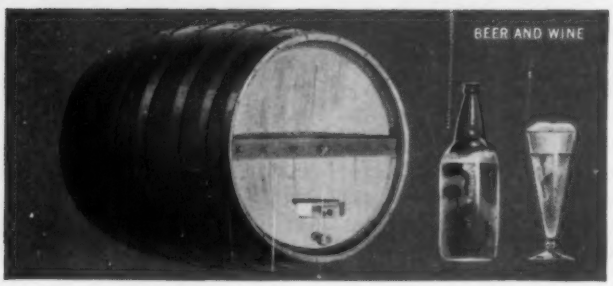
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WHAT'S HAPPENING IN RESEARCH . . .

New angle on fracture failures

In creep-rupture tests, it has been found that specimens sometimes fail at their strongest (thickest) point—in the fillet-reinforced area rather than the thinner sections where, presumably, the stress is higher.

Now, Naval Research Lab scientists have come up with findings that may explain why.

In one series of tests, at a stress of 2600 psi, ¼-in.-dia nickel specimens showed a rupture life of more than 2500 hr at 1500 F, while ⅜-in. specimens failed in less than 75 hr. At 3000 psi, the smaller specimens lasted nearly 60 hr; the larger, less than 48.

Such failures, they note, occur only in air—never in vacuum—and only under conditions where stress is low and temperature fairly high. Yet these are conditions under which, normally, rupture strength is higher in air than in vacuum.

One possible explanation: In air, at temperatures in the 1500-F range, an oxidation-strengthening occurs which has relatively deeper penetration and therefore greater effect on thinner sections than on thicker ones.

Preliminary tests appear to confirm this theory; and metallographic studies of crack patterns show that fracture generally occurs in sections containing extensive oxide-free (internal) cracks, rather than in the thinner sections where the cracks reach the surface and are oxidized. Further studies of the phenomenon are now in progress, and a report will be prepared when they are complete.

Machining may cause polymer breakdown

New evidence that mechanical forces as well as thermal and chemical attack can degrade plastics comes from a study at the Soviet High Polymer Institute.

Lathe-turning was used as the degradation method, and care was taken to hold the materials (acrylics and polystyrene) at room temperature. Say Academicans M. P. Vershina and Y. V. Kuvshinskiy:

The degree of degradation depends on the thickness of the chips, the cutting rate, and the molecular weight of the initial polymer; and rate of degradation increases as chip thickness increases. There do seem to be limiting factors, though, perhaps traceable to diffusion effects, which cause a decrease in rate of degradation with time. A report on the study appeared in *Vysokomolekulyarnyye*, Vol. 2, #10, p 1486.

Burning of metals gets top attention

What makes metals burn? The answer is important not only for missiles, but also for other high-temperature processes, and a good deal of new light is being thrown on the subject.

At this week's NACE meeting, C. J. Sterner and A. H. Singleton of Air Products will describe their work on evaluation of the impact-ignition sensitivity of titanium and aluminum alloys in liquid fluorine. They've found aluminum has little or no tendency to ignite, but titanium is quite sensitive. The tests show, however, that the geometry of the striking surface plays a major role in promoting ignition, and the tendency can be markedly reduced or increased by altering the configuration of the striker.

Their conclusions confirm an earlier report by L. E. Dean and W. R. Thompson of Aerojet-General, who also found aluminum has little or no tendency to ignite in air, oxygen or carbon dioxide at temperatures below its melting point; while titanium will burn rapidly in all three, igniting at temperatures of 1250 to 1650 F.

They also note that steel alloys with no nickel will ignite below their melting points (generally in the 2000 to 2700 F-range); but nickel-bearing steels and nickel-base alloys rarely ignite until their melting point is reached. The same is true of many cobalt alloys.

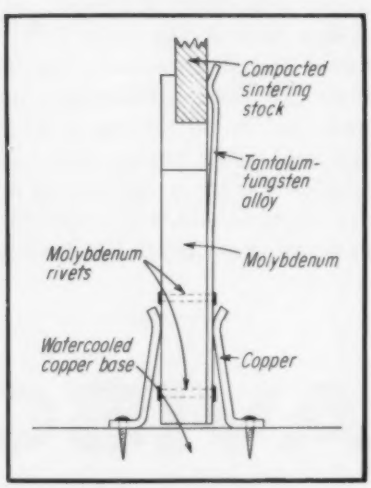
They strip away danger

Best strippable coatings for decontamination of lab equipment and other surfaces that may collect hazardous substances turn out to be two widely used materials developed for entirely different purposes.

Reporting to the Atomic Industrial Forum, three Los Alamos scientists said that after testing all sorts of paints, soaps, and soluble plastic films, they found the two materials most adaptable for efficient, remote removal of radioactive and other hazardous materials were a transparent marking ink used in brush-type pens, and an electrical sealing compound, made in England, but available through laboratory supply houses in the US. The latter is dissolved in an organic solvent for use, while the ink is already in the proper consistency. The materials are relatively inexpensive, easy to use, and resistant to water and acid fumes. **–ARG**

New contact device uses hi-temp metals

Tantalum, tungsten and molybdenum help maintain good electrical contact during high-temperature operations in this system, designed for sinter-processing at Fansteel Metallurgical Corp. The molybdenum, in the form of a machined cylinder (see diagram) makes sliding contact with copper strips attached to the water-cooled base plate, while a tantalum-tungsten spring maintains pressure on the part being sintered. Fansteel says the device operates satisfactorily in vacuum and inert-gas atmospheres at temperatures to 4900 F.



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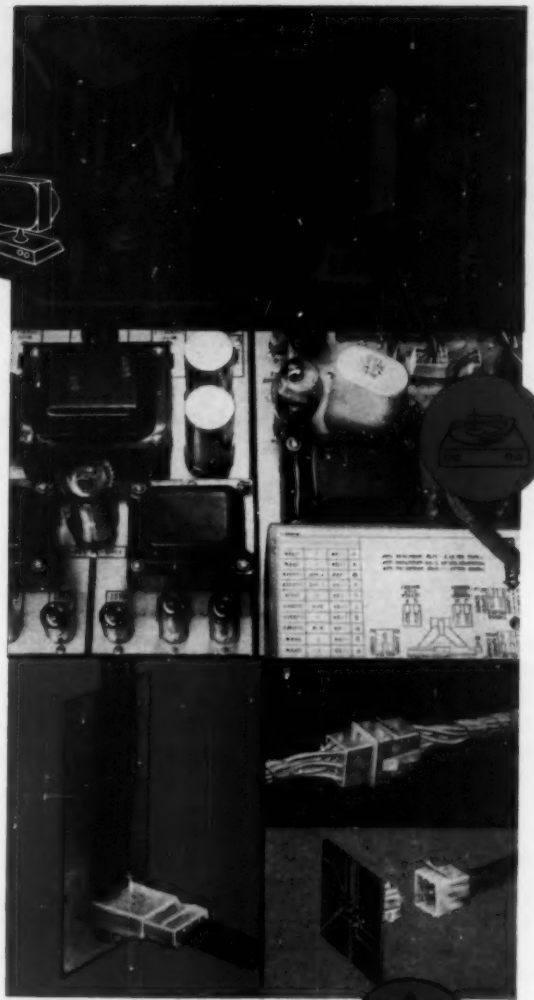

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DEVELOPMENTS TO WATCH...

Major design change improves pressure switches 3 ways

Greater accuracy, lower cost, and flexibility of design are three advantages claimed by Barksdale Valve Corp for a new line of pressure switches soon to be introduced.

Interchangeable components—capsules and contact elements—which can be attached to a standard body permit an almost infinite variation in design and also open the way to mass-production techniques (die-cast frames, for instance) that promise substantial reductions in cost. Furthermore, the new production methods—including automatic welding—promise to hold accuracy within 0.2%, as compared to the usual 1.0% or more. The switches can be used in all the standard applications—protection of hydraulic circuits, filters, compressions, and the like.

Electrical conductors improved by hi-temp design

For operation at 700 to 2000 F, Rockbestos Wire and Cable Co (Div of Cerro Corp) is developing miniature lead wire that incorporates a number of advanced material and design ideas. In one type, a stranded nickel-clad copper conductor is wrapped with glass-reinforced mica tapes and then covered with PTFE (fluorocarbon resin coated) braid protected by a special fluorocarbon enamel finish. In another, rated for short-term use at 1000 to 2000 F, the center layer is a flexible inorganic fibrous insulation. Now under evaluation are several new constructions, some using experimental high-temperature inorganic papers, which, it is hoped, will extend both the operating range and the time of service at high temperatures.

The latest on castings—bigger, purer

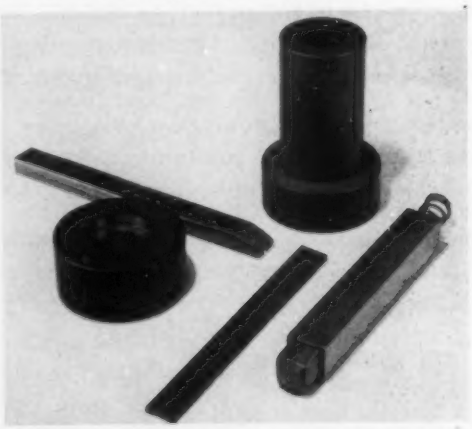
High-purity tungsten, and several new metal alloys are now being skull-cast at Oregon Metallurgical Corp—some commercially and in large sizes, others still on an experimental basis. The high-purity tungsten falls in the latter category. But Oremet has successfully produced large (240-lb) missile-nozzle castings.

Meanwhile, 98% tungsten castings, as well as 85-16 tungsten-moly shapes in sizes to 10 in. dia and weights to 220 lb are now on a nearly commercial basis. The company also claims the record-breaker among pure vanadium centrifugal castings: a 14-in., 60-lb ring; and is making 24-in. columbium alloy and molybdenum rings. The rings are not finished products, but are designed to be split and rolled to sheet. They are easier to fabricate than ingots, Oremet says.

New moldable, self-lube compositions tested for bearings and seals

Epoxy-resin compositions containing up to 80% molybdenum disulfide are under test for bearings, seals and friction strips.

One type developed by Molykote Produktionsgesellschaft (affiliate of Alpha-Molykote), is said to be readily castable, and machinable to close tolerances (see photo). The other, by P E Thomas of Ashstead, Surrey, England, is a 3-way combination. First, partly polymerized epoxy resin and molydisulfide are mixed together and ground to powder. Then PTFE (fluorocarbon plastic) resin is added to the mixture, and the composition is extruded into rods and cured.

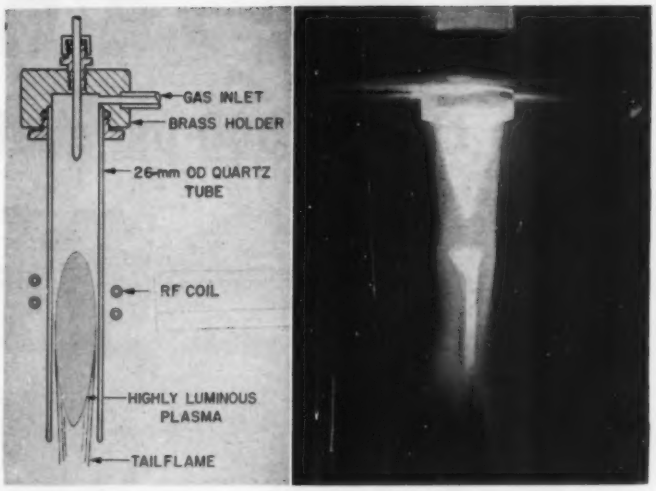


BEARINGS AND WIPERS made of new plastic compositions lubricate themselves.

Simplified plasma torch offers high stability

An induction plasma torch that consists simply of a conventional rf power supply, a solenoid coil, a gas source, and a set of connecting tubes, has been designed by T. B. Reed of MIT's Lincoln Laboratory.

As described by J. A. Kessler and R. G. Eldridge of the lab, the electromagnetic field of the coil ionizes the gas in its tube, creating a plasma that will achieve temperatures as high as 20,000 K (about 40,000 F) with a power supply of only 3 kw. Furthermore, as little as 500 w will maintain the induction plasma, and almost any gas or mixture of gases (oxygen, nitrogen, argon, hydrogen, etc) may be used.



INDUCTION TORCH operates on 4-mc power supply, propels high-temperature jet that can be used for cutting, melting, or crystal-growing (as at right).

New coatings are transparent, boilable, solvent-resistant

Coatings based on dialdehyde starch (*PE*—Apr 27 '59, p 20) now show promise for both protective and decorative use, USDA researchers report. These are acetal-type finishes that will resist attack by acetone, ethyl alcohol and sulfuric acid, are unusually hard, and stand boiling for periods as long as 10 hr. Furthermore, they can be produced at normal pressures and temperatures only slightly above 100 F. They're not yet in commercial production, but USDA's Northern Div Laboratory (Peoria) says they are ready for evaluation.

Better heating-element alloys being developed in India

Electrical-resistance alloys that show a higher electrical resistivity than Nichrome, yet contain little or no nickel or cobalt, are claimed by India's National Metallurgical Laboratory. They're iron-chromium-aluminum combinations with varying amounts of manganese, silicon, titanium, and zirconium. Additions of misch metal (rare-earth) mixtures "have also been found to be very beneficial." The alloys are readily hot-rolled, though there have been some difficulties in wire-drawing; but NML believes these can be overcome. (For news of other low-nickel alloys being developed in India, see *PE*—Dec 12 '60, p 8 and Dec 19 '60, p 9.)

Hi-temp insulation readied for vapor-deposited circuitry

As insulation for high-temperature printed circuits of the type made by evaporation of metals, Technology Instrument Corp is developing a process for applying thin silicon monoxide coatings by the same technique. The process is said to produce coatings that have excellent insulating properties, though they are barely 1000 angstroms thick.

These compounds will boost flame resistance

Plastics and resin coatings that show increased flame resistance without loss of basic chemical, physical, and electrical properties, are promised by a new group of halogen-phosphorus compounds recently announced by Monsanto Chemical.

Resins compounded with the new additives, Monsanto says, show good stability; and, while not water-white, are light in color and have little odor.

The compounds are now being evaluated by resin and fiber producers, and first reports are very good. But, Monsanto says, it will probably be late this year before sufficient data is on hand to guide commercial formulation. —ARG

new –

a LINE of 500 psi quality steel swivel joints

APPLY THIS ECONOMICAL

CHIKSAN LFS SERIES SWIVEL JOINT

TO A WIDE RANGE OF LINE FLEXIBILITY NEEDS

Equally effective on lines handling water, hot liquids, fuels or gas, the new Chiksan LFS series joint has many features to commend its use. Sweep radius minimizes flow turbulence. Bearings are factory lubricated—usually sufficient, in normal service, for the life of the joint. In-stream packing is not affected by line surge or vacuum conditions. Fabricated from carbon steel, LFS series swivel joints have a temperature rating of 225°F and up to 400°F with Viton A packing. Available in sizes of 1½″ to 4″ in eight basic configurations. For more facts on this economical Chiksan LFS series joint, please request Bulletin 11-60.

CHIKSAN

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Let your local Gates Engineer Prove Super HC Drives save space, weight, money

If you are designing a new machine or redesigning one for better performance, your local Gates Field Engineer will be glad to help you. He can show you how to take full advantage of the many opportunities offered by Gates Super HC High Capacity Drives.

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Gates Super HC Drives give you these benefits:

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Exclusive design features include:
precisely engineered arched top, concave sidewalls, Flex-Weave cover, super strength tensile construction.

Building the future on 50 years of progress

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BP-11

Gates Super HC V-Belt Drives

CIRCLE 11 ON READER SERVICE CARD

FROM WASHINGTON . . .

Navy presses for intercontinental Polaris

The Navy won't admit it officially, but a move is underway to extend range of the Polaris missile to 5000 mi. Though only a paper plan, without Defense Department approval, top Navy brass are pressing a bid for such a missile.

Unofficially labeled the A-5, the long-range version would follow the 1500-mi A-2 and the 2500-mi A-3 missiles now under development. Navy plans to extend the range of its current A-1, 1200-mi Polaris, to 1500 mi by early next year and have the 2500-mi A-3 version in service by 1964.

Some observers say a 5000-mi version of the Polaris could be developed by around 1970. A big advantage of such a missile is that it would double the operating areas of the Polaris-toting nuclear-powered submarines. This would greatly increase their ability to remain undetected by enemy forces.

Navy also plans to use a beefed-up Polaris to put satellites into orbit. Known as project Sea Scout, the vehicle would be used for ocean launchings of satellites, such as the Navy's transit navigation satellite.

The advantage of such launchings is that they could be made from geographically ideal sites rather than limited to Cape Canaveral or the Pacific missile range on the West Coast.

Missile launchers go on aluminum diet

Weight added to the Minuteman mobile railroad launchers is forcing a materials substitution. Weight comes primarily from extra equipment, such as air-conditioning units, that have been added to the rail cars.

The extras have added about 20% to weight of the railroad cars, and have required designers to substitute aluminum wherever possible. Each car must be trimmed to about 300,000 lb for final production models. Work is now progressing on the second of the five development cars slated for the Minuteman program before production begins.

Maritime Administration calls for better ballast pump

The Maritime Administration has called for proposals for a new oil and water separator. The agency is asking for a feasibility study, design criteria and a pilot model. Offerings must be submitted to the agency by April 20.

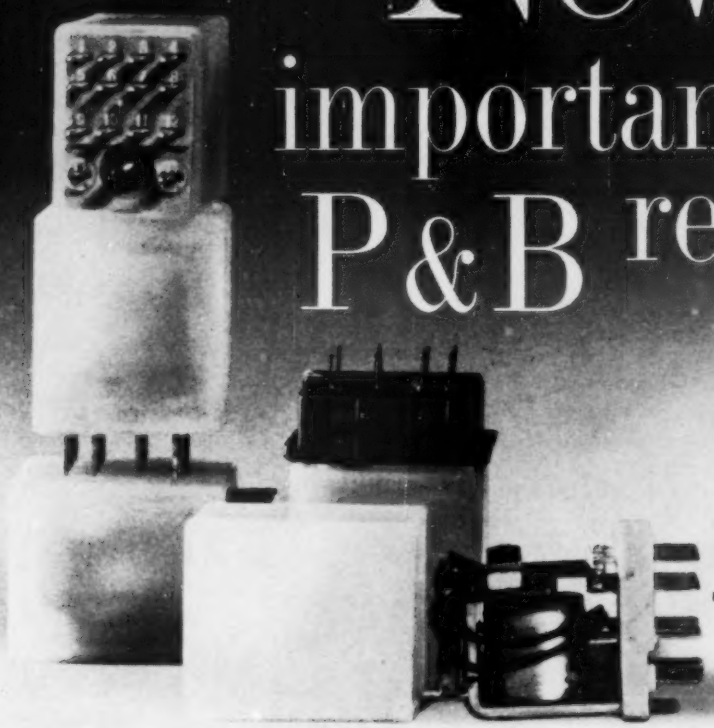
The pump that the Maritime Admin is after is needed to prevent pollution of the ocean when merchant ships pump ballast. It must be compact, simple in design and operation, and constructed for minimum maintenance and operating care. Oil separated from sea water would be recovered and made suitable for burning in ship's boilers.

Air Force issues Space Age dictionary

The Air Force has put out a new glossary of missile and space terminology. The 75-page booklet lists some 1300 terms and definitions ranging from "ablating materials" to "zuni." It is the most comprehensive list published to date in the field. Titled Interim Aerospace Terminology Reference, the publication is available from the Office of Technical Services, US Dept of Commerce, Washington 25, DC. Order PB 161913, Price $2.

CIRCLE 13 ON READER SERVICE CARD→

a New and important P&B relay . . .

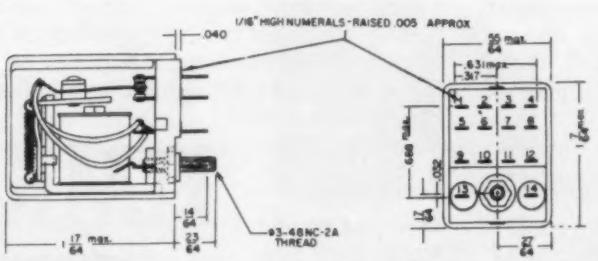


KHP SERIES SHOWN ACTUAL SIZE

having rare longevity

This small, 4-pole relay has the happy faculty of maintaining its original operating tolerances over an exceptionally long life. Example: tests (by customers!) show this relay has variations in electrical characteristics of less than 5% after more than 100 million operations.

But that's far from all. This is a *small* relay . . . about a one inch cube. This relay is easy to install using the conveniently spaced solder lugs or a socket. Thus you save time and production costs. This relay is versatile . . . its 4PDT contacts will switch loads from dry circuit up to 3 amperes. This relay—well, why not order samples and see for yourself! Order today from your P&B representative or call us at Fulton 5-5251, in Princeton, Indiana.



KHP SERIES SPECIFICATIONS

CONTACTS:
Arrangement: 4 Form C, 2 Form Z.

Material: ½" dia. Silver standard. Silver cadmium oxide and gold alloy available.

Rating: 3 amps @ 30 volts DC or 115 volts AC resistive for 100,000 operations.

COILS:
Resistance: 11,000 ohms max.

Temperature: Operating Ambient: —45°C. to +70°C.

Power: 0.5 watts min operate @ 25°C. 0.9 watts nom. @ 25°C. 2.0 watts max. @ 25°C.

TIMING VALUES:

Nominal Voltage @ 25°C.	Max. Values
Pull-in time	15 ms
Drop-out time	5 ms

INSULATION RESISTANCE: 1500 megohms min.

DIELECTRIC STRENGTH:
500 Volts RMS 60 cycles between contacts.
1000 Volts RMS 60 cycles between other elements.

MECH. LIFE: In excess of 100 million cycles.

SOCKET: Solder lug or printed circuit terminals. Available as accessory.

DUST COVER: Standard.

TERMINALS: Solder lug and taper tab.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

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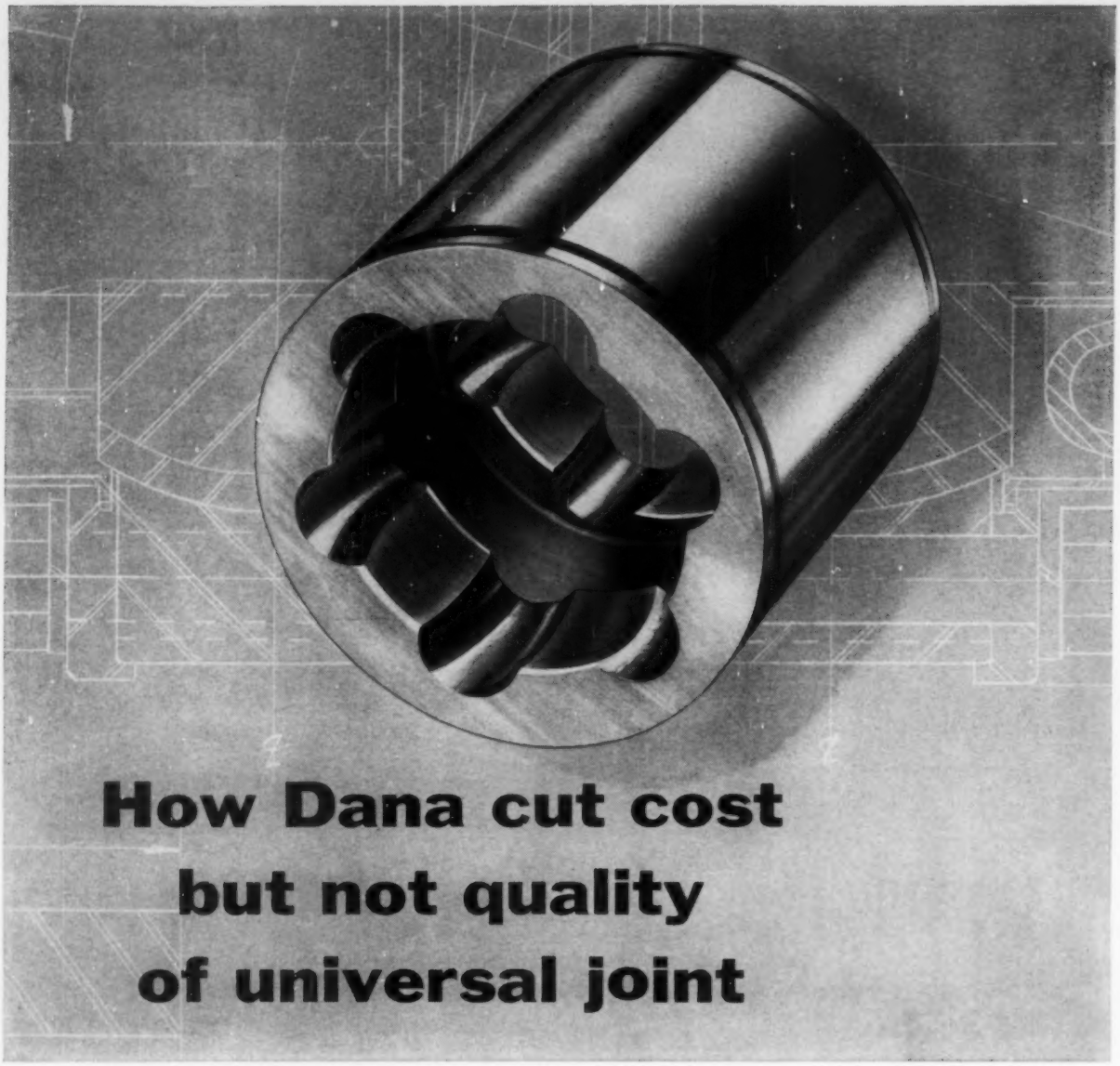

How Dana cut cost but not quality of universal joint

Before the development of the constant velocity universal joint, transmitting uniform rotary motion through a varying angle from shaft to shaft was unsatisfactory at best. Now this type of joint has hundreds of successful applications, including marine and aircraft, road building and mining machines, and machine tools. And with Dana Corporation's Con-Vel Division Rzeppa universal joints, motion transmission is virtually vibration-free. Their disc-type double joint, made from two forged and machined single units coupled together, had one probem—high manufacturing cost. Dana wanted to reduce this cost while maintaining quality.

After consulting with Timken Company metallurgists, Dana redesigned and switched to Timken® seamless steel mechanical tubing for the double outer race of the disc. Savings were immediate and sizable. With the tubing, there's no hole to drill, less machining. Quality was maintained and strength actually increased because of the fine forged quality of Timken rotary-pierced tubing.

Find out how versatile Timken seamless steel tubing—targeted during manufacture to your end use—can save you time and money on your hollow parts. Write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

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***Fine Alloy* STEEL**

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

THE ENGINEERING WEEK

Government Patent Policy Called Sound by Independent Study

WASHINGTON—An independent study of the government's controversial patent policies has found that they are working reasonably well and that there is no urgent reason to alter them now. The report was made for the General Services Administration (the government's purchasing and housekeeping agency) by the Patent, Trademark and Copyright Foundation of George Washington Univ.

The crux of the controversy is whether title to patents resulting from government-financed research should be assigned to the federal government or retained by the company. When title is assigned to government, the administering agency usually licenses inventing companies to produce the item. This practice is generally followed by the AEC.

When title is retained by the company, the government gets an unrestricted, royalty-free license, empowering it to find producers for the item. This practice is generally followed by the Department of Defense.

The study found that controversy over who should hold patents is raising a tempest in a teapot, because relatively few patents have emerged from government R & D. Though the US financed over half of all R & D between 1946-59, this effort yielded only 32,000 patents. During the period, 527,000 inventions were covered by patent.

At present, the differing policies followed by Defense and the AEC are fairly well tailored to their individual needs, the study finds. A uniform policy imposed on the agencies might limit their flexibility in dealing with contractors.

According to the report, the policy followed by the Dept of Defense is appropriate when the government is dealing with a broad range of technologies and is primarily interested in obtaining better equipment. The policy enables industry to commercialize inventions resulting from government R & D.

In the postwar period, about 23,000 patents have been assigned to private owners, mostly by the Defense Department. Actually only a small proportion of them—perhaps 13%—have produced commercial outcroppings. The only major commercial utilization uncovered by the authors was found in a university. Nevertheless, the report found industry firm in the belief that patent rights are bait that helps attract R & D talent to government projects to advance technology.

The title policy followed by the AEC is useful where a government agency seeks to foster and guide development of a new industry. The report says that perhaps only a strong, tough-minded agency pushing a new technology can best serve public interest by retaining title to patents. The AEC has acquired title to about 2500 patents and issued production licenses for about 1350 of them. Con-

Column Buckling Checks Column Strength

A new analytical method for determining the compressive strength of columns at high temperatures, and based on short-time, stress-strain properties of materials, is enabling Battelle Memorial Institute metallurgists to predict the stiffness of columns under conditions encountered by aircraft and missile structures. Previously, it had been impossible to predict the properties of a column in which metal creep caused the shape to change continually. With the equipment shown above, validity of the analytical technique has been confirmed by applying compressive loads up to 2000 lb to columns at temperatures of 325 F. Program is sponsored by the US Air Force Aeronautical Research Laboratory.

tractors have retained title to another 700 inventions, most of these outside the atomic field.

But the report warns that AEC policy is primarily suitable to a nascent industry. Once an industry approaches commercial stage, retention of patents by government may slow development. The report adds that AEC's administration of patents may be somewhat rigid. Scattered evidence suggests that a few contractors have refused AEC contracts or have failed to press ahead with developments as rapidly as possible.

The charge that a policy of permitting companies to retain patents leads to industrial concentration is unfounded, the report states. Such concentration is said to derive more markedly from initial R & D expenditures than patent policy. Furthermore, the report finds evidence that some vigorous and progressive small companies have benefited from the policy.

The report was written by Donald Stevenson Watson and Harold F. Bright. Arthur E. Burns served as consultant.

A similar study recently made of the patent policies followed by the Department of Health, Education and Welfare likewise found no need for serious change. This study suggested that government retain all rights to products developed through use of federal funds. This is already HEW policy, except for the cancer chemotherapy program. ■

Variable Vanes Spark New Chrysler Turbine

DETROIT—A variable-pitch nozzle system which directs hot gases against turbine blades has been designed into a new gas turbine engine by Chrysler Corp. The new system enables the engine to generate 140 hp, and achieve increased efficiency at "low" speeds.

The 2-stage turbine uses hot combustion gases to spin two turbine wheels at speeds of 45,000 rpm at temperatures of 1700 F. Weighing approximately half that of a cast iron engine, the new powerplant is started by its own high-speed, battery-powered starting motor. Intake muffling is said to be satisfactory with exhaust reported cooler than that of comparable piston engines. ■

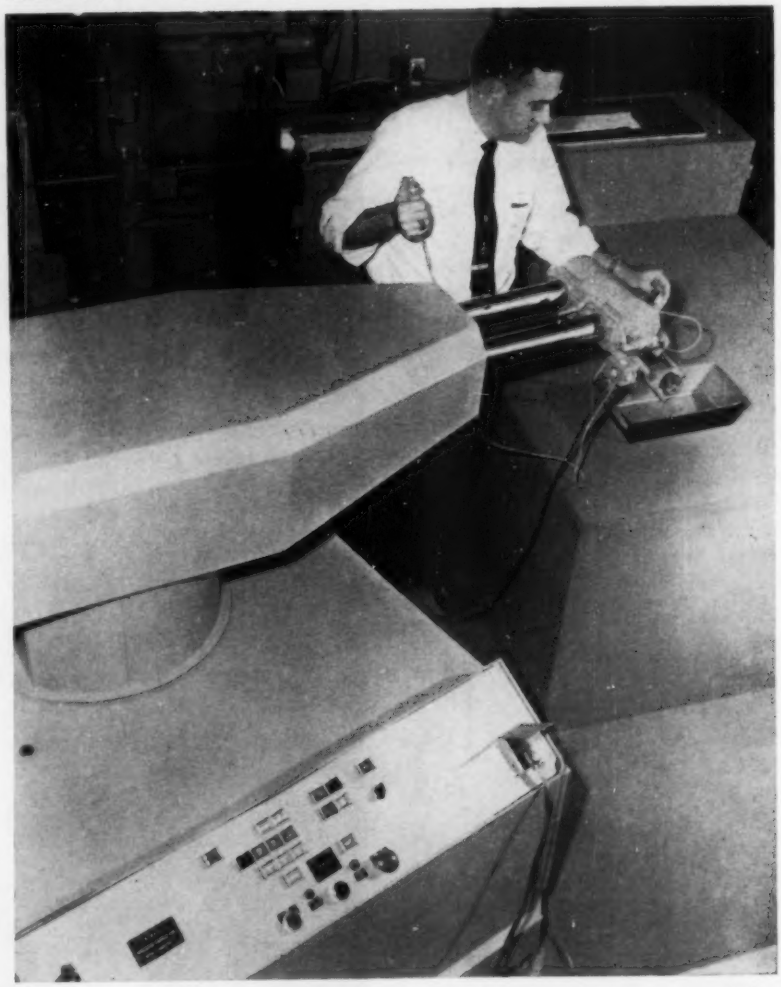
Same Machine Straightens, Die-quenches Mill Shapes

MILWAUKEE—Straightening and die-quenching of channels and other mill shapes—which will permit use of relatively inexpensive materials in simplified designs for many structural members—is now done simultaneously in a new machine developed by A O Smith Corp of Milwaukee.

This new technique is aimed especially at truck-frame designs, where the need for weight reduction has led the industry to aluminum or expensive high-strength steels.

According to A O Smith engineers,

Robot Arm Lends a Hand to Production



Designed to speed factory production and cut costs by taking over repetitive routines, Unimate, designed by the Consolidated Diesel Electric Corp, Stamford, Conn, duplicates the functions of the human arm. A magnetic memory drum, which can remember 200 sequential commands, directs the arm according to stored information. To teach Unimate a task, the hand is led to the desired positions by applying finger pressure to white buttons on the learning controls temporarily attached to the hand. Endpoint of each movement is recorded by pushing the "record" button held by teacher. Memory drum's surface consists of segments of magnetic material which can either be magnetized or demagnetized in a pattern conforming to recorded instructions. In operation, drum steps from position to position and awaits signal that arm is in correct location before continuing. Hydraulically operated arm telescopes from 3 to 7 ft, sweeps 220° in a horizontal plane and 60° vertically. It can lift up to 75 lb from within 4 in. of the floor to 90 in. above floor. Machine can be moved with a fork lift truck, has variety of "hands," and sells for $25,000. More details in next week's Product Design section.

inexpensive intermediate-manganese steel is heat-treated to produce high-strength structural members such as truck side rails. These rails, heated to 1650 F, are transferred from the furnace to the die-quenching machine, where dies automatically straighten them while still in the plastic range. The machine holds the rails here during a forced quenching cycle. Straightening of the rails while in the plastic state eliminates residual stresses.

Later, the quenched members are drawn to a hardness of 280 to 285 Brinell. Properties then are 117,000-psi yield strength, 127,000-psi ultimate tensile strength and 17% elongation. These compare favorably with the properties of more expensive alloy steels such as SAE 8620.

Before the new die-quenching machine was developed, side rails and other structural members would warp, bend and twist during heat treatment, requiring expensive hand-straightening operations.

—Felix Giordano, Regional Editor

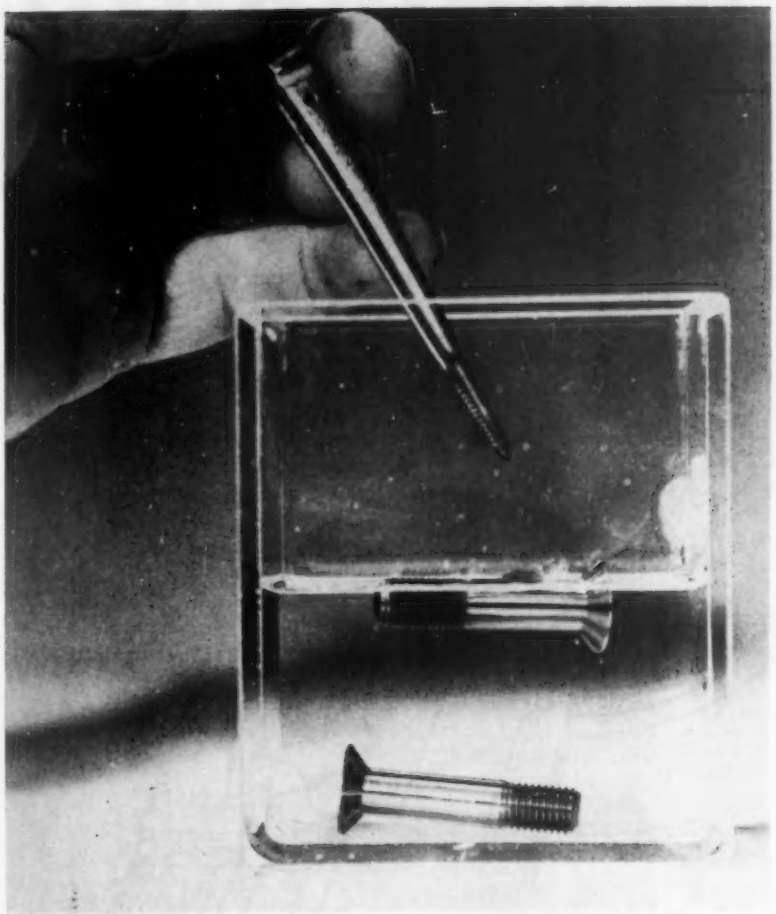
Metric System on Horizon for British Currency, Weights

LONDON—Pressure for the adoption of a decimal system in Britain to be applied to currency, and perhaps for weights and measures too, is growing.

A pamphlet issued by PEP, Political Organization and Planning, said decimalization of British currency and measure is inevitable within 50 years. PEP urged a switch to the metric system, pointing out that in coinage the longer the delay, the greater the expense; while in the matter of weights and measures, the longer the delay, "the heavier the handicaps to exports, particularly of high conversion-value goods such as precision engineering-instruments and machine tools."

The Federation of British Industries has written the Board of Trade urging that Britain adopt decimal coinage as "an essential step toward the use of the metric system of weights and measures."

In Parliament, a Conservative member has submitted a motion with all-party support urging the government to introduce a decimal coinage system at an early date. The Commonwealth Prime Ministers Conference this month will consider such a system for the UK and the Commonwealth. ■



FLOATING BOLT is made of beryllium; its submerged companion is titanium—a rival light metal. They are submerged in a water solution of silver nitrate. Titanium weighs about 2½ times as much, but its shear strength on a pound-for-pound basis is only about 2/3 that of beryllium.

Beryllium Bolts Vie for Space Age Jobs

JENKINTOWN, PENNA—Beryllium, the wonder metal that was expected to revolutionize the aircraft industry some 30 years ago, may do it today for the space industry. Bolts, nearly twice as strong, on a pound-for-pound basis, as the best comparable steel bolts, are being produced by Standard Pressed Steel Co here.

Translated into a space accomplishment, this means that 1 lb of beryllium bolting can replace 2 lb of steel in a missile or satellite. At present, the cost of hurling 1 lb of payload into orbit is estimated at $1 million.

BRITTLENESS A BOTTLENECK

Heretofore, brittleness has precluded the use of beryllium for fasteners. But research at SRS has shown that brittleness is caused by notch sensitivity—sensitivity to surface discontinuities. After identifying the problem, engineers have overcome much of it by eliminating microscopic surface scratches that occur during fabrication and by strengthening the notches that are necessary, such as head and thread (*PE*—Nov 14 '60, p 75).

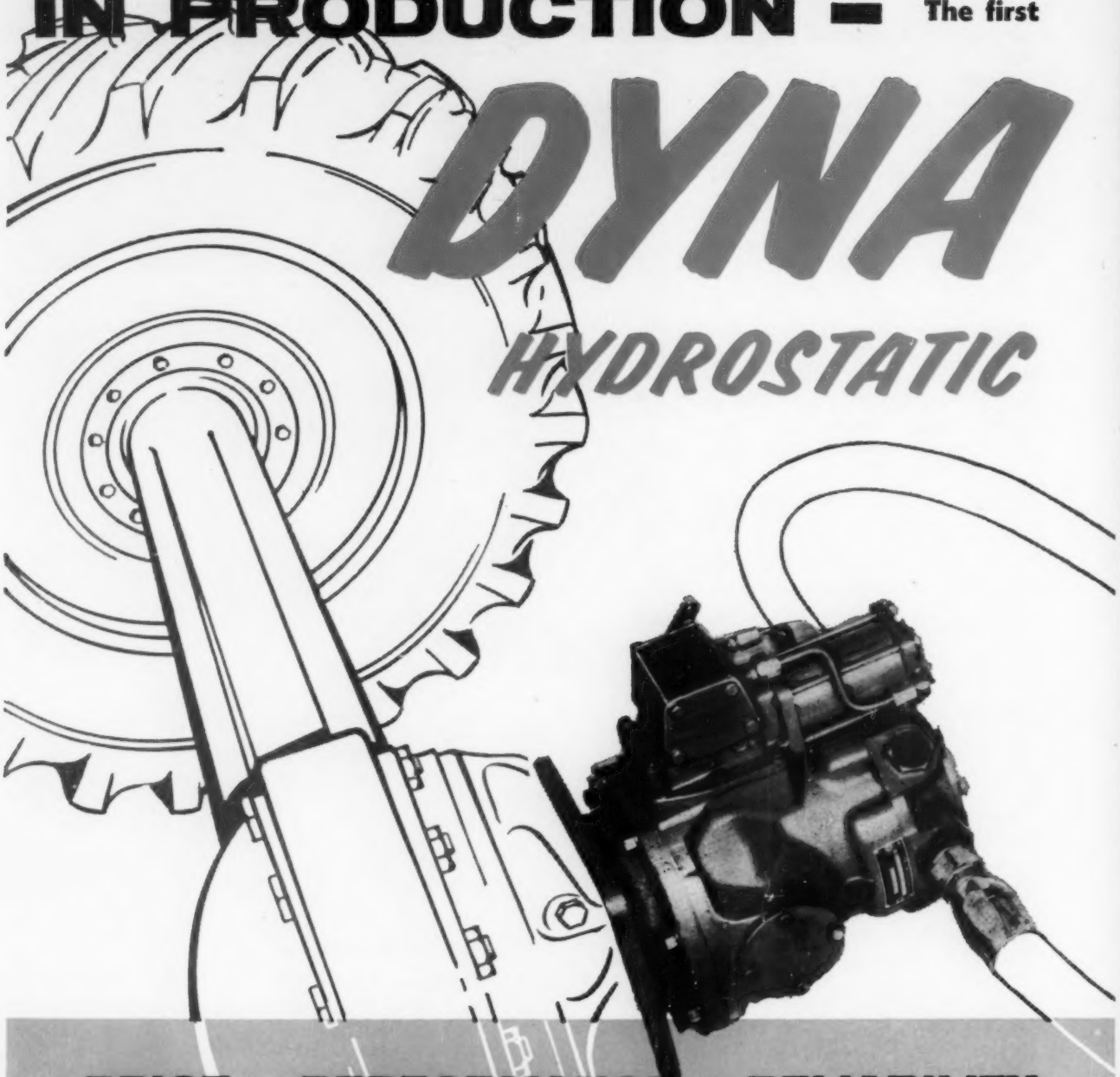
A chemical surface finish is used to eliminate detrimental scratches that occur during finish grinding. And notches are strengthened by designing bolt threads with unusually large, rounded-root radius—1½ to 2½ times' conventional rounded roots.

Application of the chemical finish is said to improve transverse ductility of the fasteners so that bolts triple their normal strength in a double-shear configuration. Minimum shear strength is put at 60,000 psi. Fatigue

continued on page 20

IN PRODUCTION — The first

DYNA HYDROSTATIC



PRICE . . . PERFORMANCE . . . RELIABILITY

After four full years of development and test—both in the lab and in the field—DYNAPOWER Hydrostatic Transmission Systems are ready to begin working for you.

DYNAPOWER gives you infinitely variable speed—in either direction—and full torque—even at idle speeds—*without clutches or gear changers!*

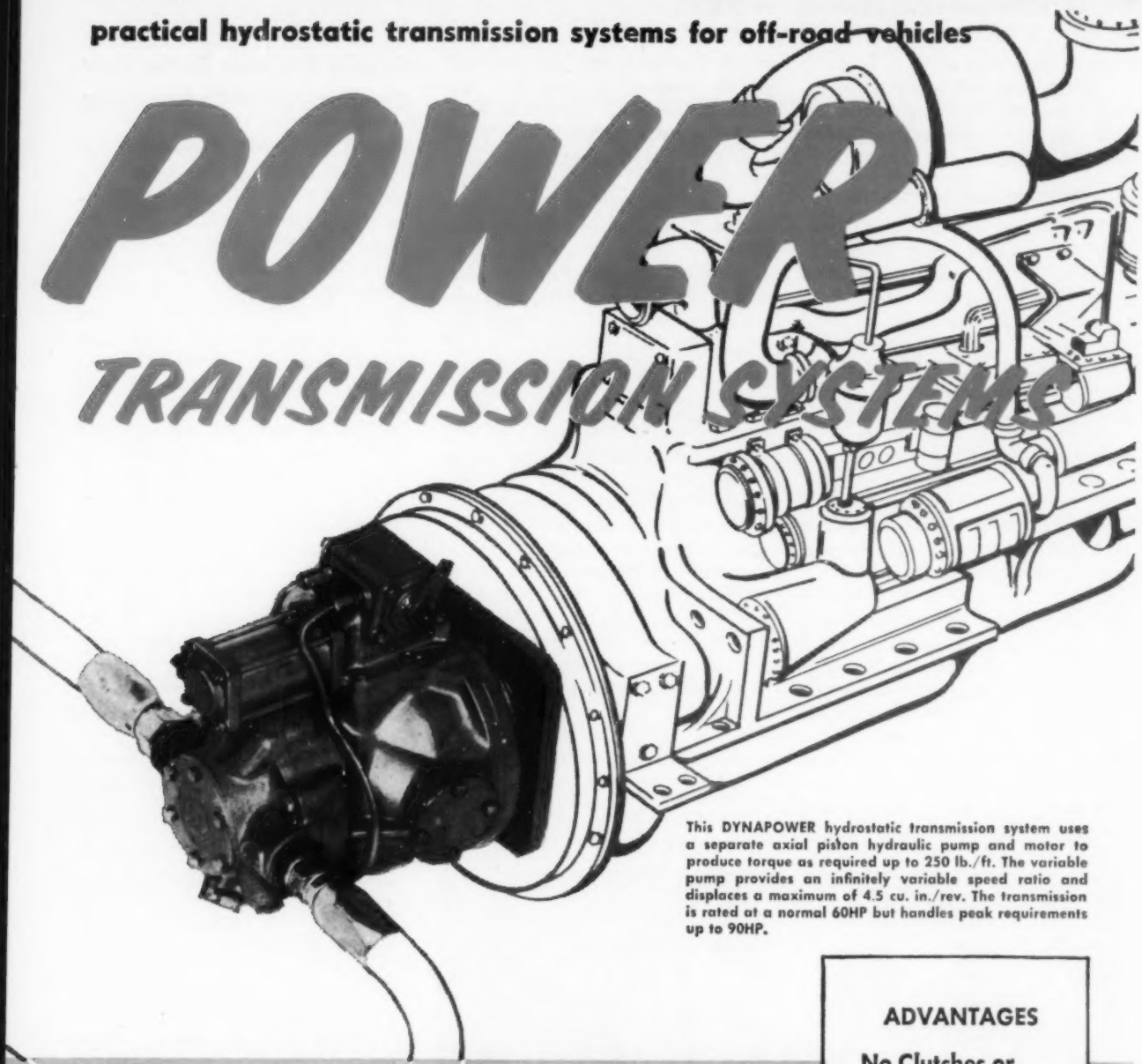
DYNAPOWER-ed vehicles will perform more work faster because their torque/speed characteristics will be matched to the requirements of the job.

Fewer controls make it easier for the operator—yet he'll have better control plus faster, smoother response. DYNAPOWER—the "two-way" transmission—reduces brake maintenance because service brake needs are handled by the transmission—*hydrostatically.*

New DYNAPOWER hydrostatic transmission systems are available with controls to handle almost every need—in plant as well as vehicular. Transmission output can be governed with any of the

practical hydrostatic transmission systems for off-road vehicles

POWER TRANSMISSION SYSTEMS



This DYNAPOWER hydrostatic transmission system uses a separate axial piston hydraulic pump and motor to produce torque as required up to 250 lb./ft. The variable pump provides an infinitely variable speed ratio and displaces a maximum of 4.5 cu. in./rev. The transmission is rated at a normal 60HP but handles peak requirements up to 90HP.

WITH DYNAPOWER

following: manual control, hydraulic servo control, constant speed control, constant HP control, pressure compensator control, hydraulic servo control with pressure compensator override, temperature sensing control. DYNAPOWER hydrostatic transmission systems are ready to work for you.

To know more about DYNAPOWER, write to:

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
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ADVANTAGES

- No Clutches or Gear Changers
- Infinitely Variable Speed
- Faster, Smoother Response
- Full Torque at Low Engine RPM
- Reduced Brake Maintenance
- Simplicity of Operation

continued from page 17

strength is also said to be raised to 40,000 psi, making them capable of good structural performance under dynamic loading.

FORESEE NUCLEAR APPLICATIONS

While initial applications of beryllium bolts are expected in the missile program, SPS anticipates many other applications for the light metal. The material has outstanding nuclear properties; its high thermal conductivity makes it a good heat sink material; and its resistance to atmospheric corrosion equals that of aluminum. Beryllium also has a higher melting point (2350 F) than most other light metals.

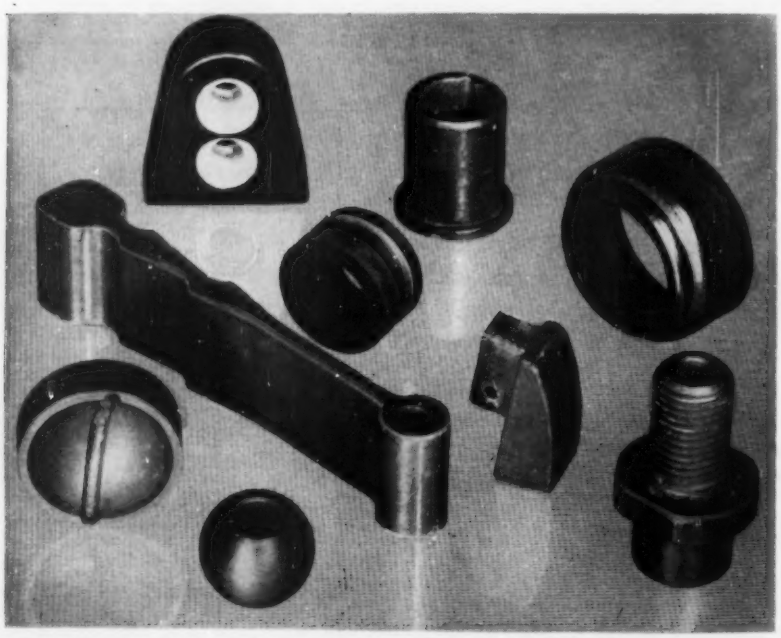
At present, bolts are available in standard shear bolt configurations through ⅜ in. dia. According to company representatives, SPS is confident that it can develop a tension bolt for wider applications in the very near future. ■

Moldable Urethane Rubber for Mass Production

PITTSBURGH — Abrasion-resistant urethane elastomers have not been specified as widely as they might be because, until recently, all parts had to be made by a costly, time-consuming, liquid-casting technique (*PE*—Sep 16 '57). Now, fully compounded and partly cured urethanes are available which can be injection-molded or extruded on conventional equipment to give elastomeric end products like the automotive parts shown below. One of the new compounds is Texin 192 A, moldable urethane developed by Mobay Chemical Co. An extrudable grade, Texin 280 A, has also been developed. Work to date on the new compounds, available in developmental quantities, has not yet established whether post-curing is necessary to obtain all ultimate properties as it is for cast urethane elastomers. The brief property data tabulated below are for material post-cured for 16-24 hr at 230 F. **—Ford Park**

Properties of Molded and and Extruded Urethanes

	Type 192 A	Type 280 A
Hardness, Shore A	92-94	80
UTS, psi	4400	5500
Elongation (break, %	600	600
Elongation set, %	45	30



AUTOMOTIVE PARTS of cast urethane rubber are used on many foreign cars. Selection above includes: door latch shock mount (upper left), sleeve bushings (upper center and center), grease seal (upper right), door latch spring and door latch (center), ball and socket joint (lower left), and grease fitting (lower right). Parts that can be cast, says Mobay, can be injection molded or extruded.

Dummy Engineer Shows How Companies Handle Recruiting

NEW YORK—Here's confirmation for the oft-heard plaint that many companies with intensive engineering-recruiting programs either fail to answer resumes or do so in a perfunctory way. The validation comes from a survey of recruitment practices followed by 100 US corporations. It was conducted by the Equity Advertising Agency here.

The agency pollsters pulled a spoof on the surveyed companies. First, they created an imaginary engineer with high educational qualifications: an MS degree in electrical engineering from a school generally ranked among the nation's 10 best, plus supplementary graduate studies in physics. Upon completion of his MSEE, the imaginary engineer joined a large East Coast electronics firm, where he supposedly rose from junior engineer to group leader, supervising 8 professionals and several technicians during his 9-year employment. He was pictured as being in his mid-thirties, married and enjoying robust health.

Next, Equity worked up an appropriate resume and mailed 100 individually typed copies with covering letter to firms having intensive recruiting programs. (With some cunning, typist of the resume added an erasure or two to suggest that the engineer himself had typed the manuscript.)

CAME THE DELUGE

Acknowledgments began arriving the day after the mailing—but 3 months later, 11 companies remained to be heard from. About half the replies came within 9 days; the remaining acknowledgments drifted in up to 38 days later.

Companies answered by telegram (18), and by mail (71) including special delivery and airmail. Some of the most dilatory elected to telegraph. Most of the letters (42) asked the engineer to fill out an application blank; others asked him to arrange an interview immediately (10), or at leisure (2); or denied they had job openings (9).

According to the report, only 17 of the companies showed evidence of personal interest in the applicant through their replies. Generally, the personal

touch came from small companies, who were also the fastest to acknowledge the job inquiry. By far the most effective letter was said to have come from the engineering manager of a relatively small, but growing, company. Moderately long, the letter described areas in which the applicant would work, along with his future prospects with the company.

The bulk of the replies were found to follow a standardized format—approximately one-fourth ended with the ever familiar "Thank you for your interest in (name of company)." Fourteen companies responded with form letters (one was on the back of a post card.) With a hint of scorn, the survey further reported that misspellings and grammatical errors were common in replies and in one large, apparently secretary-less company, the signer amateurishly typed his own letter. Many of the companies included elaborate recruitment packages with four-color brochures in their replies, which were generally slow to come. ■

Cruises 3 Inches Above Ground

Here's Bell Aerosystem's experimental version of a ground-effect machine. This 2000-lb vehicle operates about 3 in. above ground, is powered by a 65-hp automobile engine driving a fan mounted horizontally amidship. The fan drives air under the vehicle to form the pressure pocket that provides lift. Called the ACV (air cushion vehicle), it is controlled by metal flippers which rim the lower sides and regulate escape of air from beneath the craft. The 18-foot-long ACV is said to be capable of 15-mph ground speeds while carrying three passengers. It can be swung around within its own length, hover over the ground, and perform forward, sideward, backward and turning maneuvers.

Thermoelectric Cooling Goes Commercial

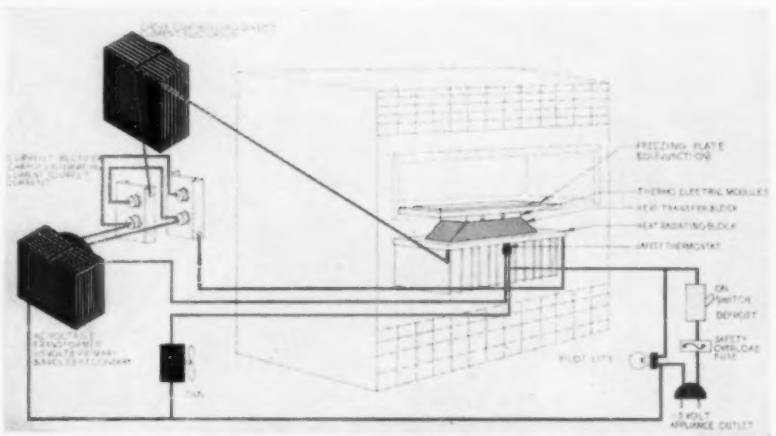
NEW YORK—Thermoelectric cooling is leaving the laboratory and entering commercial application. The Norge Div of Borg-Warner Corp is delivering 500 thermoelectric refrigerator-freezers to Sheraton Corp of America for its new Chicago hotel.

Reported cost is less than $200 per unit and expected operating rate is about 3¢ per day. The refrigerator-freezer is ½ cu ft and freezes an 18-cube tray—about 24 oz of ice—in 6 hours; requires 22 amp at 2.4 v dc.

The thermocouple is formed of alloys of bismuth and tellurium plus smaller amounts of an impurity element to get an electron flow. These metals, says Norge engineers, have a figure of merit of 3 (a rating based on electrical conductivity, thermal resistance and Peltier coefficients). For comparison, the best combination of metals three years ago gave a value of 0.6. Within three to five years, materials development may up the present value to 10 or more.

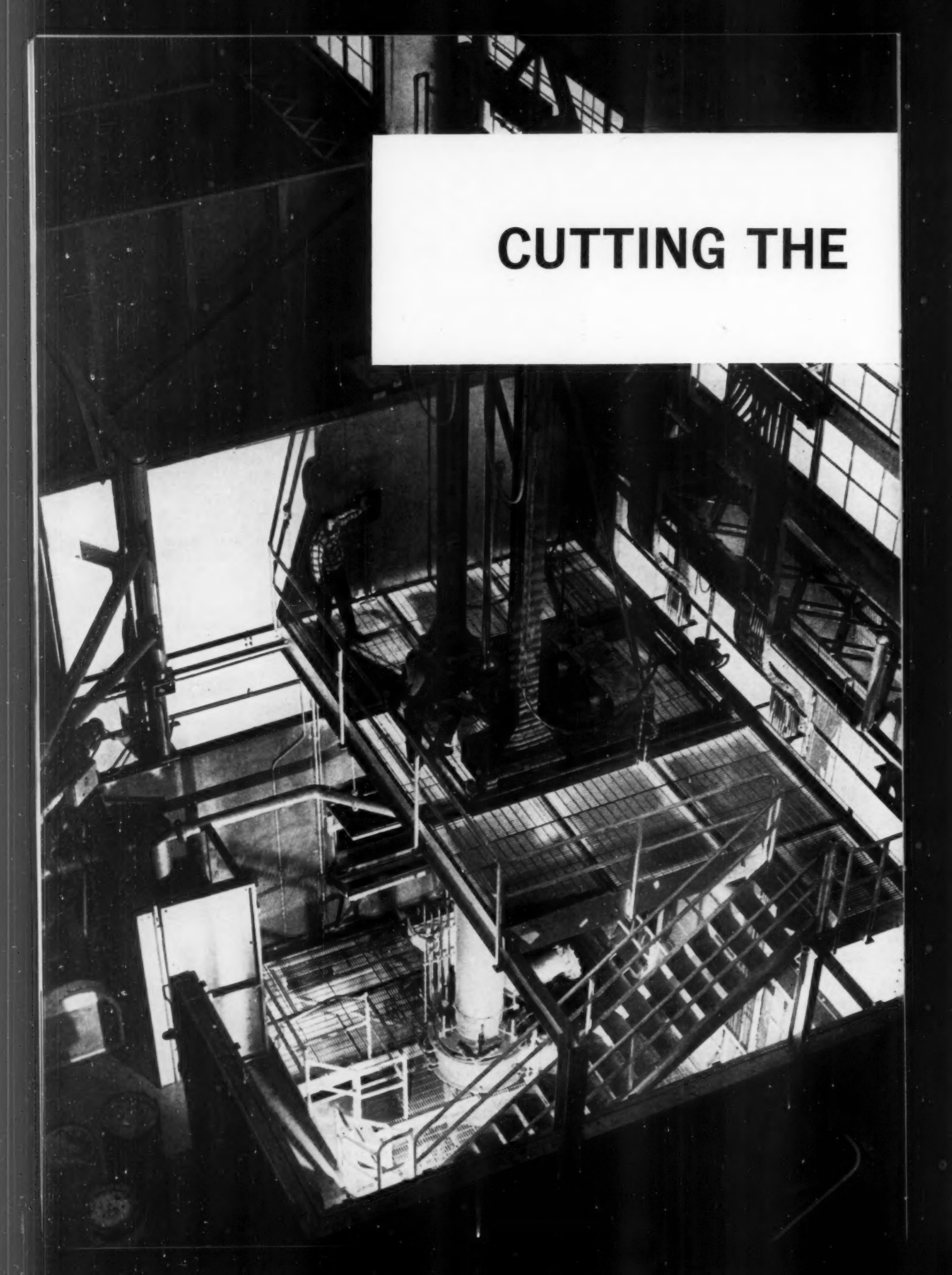
One disadvantage of these thermoelectric devices is the limited temperature difference between the cooling plate and ambient temperature—about 80 deg F. In a 90-F room, for example, assuming a perfect heat-dissipating system on the hot-junction side, the cold plate would probably be no colder than 10 F. Performance is further affected by the heat generated by the current passing through the element, which is also dissipated through the hot-junction plate. Norge is using a fan to force air over the radiating fins to increase the heat-transfer rate.

Sheraton believes the units will pay for themselves in reduced maintenance costs and added convenience for patrons. With no compressor or refrigerant fluid, about the only maintenance is pilot-light replacement. ■



THERMOELECTRIC REFRIGERATING SYSTEM consists of a primary ac power supply and a secondary dc rectifier unit; 115 v ac runs the 10-watt air-circulating fan that cools the hot-junction fins. It is stepped down to 5½ v ac at the transformer. Heat-pump action of the thermocouple begins when a constant flow of low-voltage dc passes through it. Dc is obtained by passing the low-voltage ac through silicon rectifiers, and uniform voltage is controlled by the filter choke. About 3.1 v is lost between the transformer and the thermocouples, but sufficient power is retained to pump the heat in the insulated chamber through the thermocouples to the hot-junction plate and radiating fins.

CIRCLE 22 ON READER SERVICE CARD→



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POINTS OF VIEW

THE QUESTION: *When Should an Engineer's*

"Shortly after his birth . . .

J E McKee
Professor of Engineering in Environmental Health
California Institute of Technology

and it should continue throughout his life, for he must ever keep alert to scientific discoveries, technological improvements, and changes in the social, political, and economic climate. Engineers of today and tomorrow should be truly professional men whose background is characterized by the breadth of a liberal education and the depth of a firm foundation in mathematics and science.

"Education in engineering subjects, in the application of scientific and economic principles to specific problems of synthesis, design, and operation, is dependent upon a thorough and sound knowledge of basic sciences. With the intensification of science training and the desire to provide a strong core of humanistic-social subjects, it has become desirable to postpone engineering sciences, such as fluid mechanics, solid mechanics, and thermodynamics, to the latter part of the undergraduate program and to relegate courses in the practical aspects of enginering to post-baccalaureate education.

"In effect, then, the trend in engineering education is toward 'pre-engineering' on the undergraduate level, to be followed by advanced study and research in graduate or professional schools. In this respect, engineering is rapidly approaching the educational pattern of medicine, law, theology, and other learned professions. The future of true engineering education lies in the development of professional schools on the post-baccalaureate level to which an applicant can be admitted only after he has had a strong undergraduate program in mathematics, basic sciences, humanities, and engineering sciences."

"The freshman year in highschool . . .

George A Rietz
Consultant—Educational Relations
General Electric Co

when so many decide not to take algebra. It certainly is not safe to select any later date for beginning the educational fundation for engineering. But only when the shortage of college graduates revealed the number of high-school graduates unprepared for college, did industry and the professions focus attention on highschools. Only those students who have done well and have taken certain courses through highschool should be encouraged to attempt engineering or science in college. Very few sophomores and juniors are able to make up courses they should have taken earlier.

"But do enough students graduate from the eighth grade with adequately developed abilities in arithmetic, reading, and communications? Beyond technical ability and skills, essential qualities of personality and character are largely established by then. And how highly developed is motivation—so essential to successful accomplishment during highschool and life? Once more, attention must be extended to still a lower level—the elementary schools, if the needs for educated people are to be met. Engineers and all of us, as parents, citizens, or professional workers, should develop a healthy and sympathetic interest in cooperating with education at all levels. Teachers and administrators need help to: motivate students, provide better guidance and planning, communicate job requirements, establish higher performance standards, discover more effective teaching methods, and get parents and communities to accept them."

Technical Education Begin?

"Specialization can wait . . .

The sooner in life a student begins narrowing his studies, the less his chances of being a really first-rate creative engineer or scientist. Obviously this deferral of technological education cannot go on forever and the present curriculum in most colleges is designed as a compromise between teaching students a workable minimum of basic science and enough engineering principles and practice so that they may be of some value to their employer shortly after graduation. Their engineering education will be continuing at a very high rate in the first few years of professional life. A saturation point will be reached for most people, depending on how intelligent they are, the quality of their training in fundamentals, how hard they work, and how much natural personal drive and curiosity they are blessed with. I advise against specializing until the last possible moment. I cannot emphasize this point too strongly to highschool students. They should stick with more difficult and less descriptive courses, even though it is not immediately apparent to them what eventual use is to be made of these subjects. I am sure that every practicing engineer could give many examples of some hitherto unused methods or ideas which have been lying dormant in the back of his brain somewhere for several years. The old truism about success coming to those who are prepared for it applies very nicely here."

Harold W Paxton
Associate prof, Metallurgical Engineering
Carnegie Institute of Technology
(Winner of American Society for Metals' Bradley Stoughton Award as 1960's outstanding young teacher of metallurgy)

"When the child learns the word 'why' . . .

'Why doesn't the building fall down?' 'Why does it rain, Mommy?' It begins when Mommy tries to give a simple explanation, other than giving credit to the Almighty, of why it rains. With some children, simple, sketchy explanations of scientific phenomena will always suffice. But with many others there is a natural interest in finding out more about the condensation of the aqueous vapor in the atmosphere. This early scientific interest should be cultivated for the good of our nation. If we in education do not cultivate it, we are guilty of a grievous error. If a child has exceptional musical ability we don't stop him from advance study by saying that a student his age should only play 'Country Gardens' and should not attempt a Bach fugue. The same reasoning should apply to science, engineering, or any other aptitude.

"We at the Franklin Institute acknowledge that there is some danger in presenting advanced subject material to students at the secondary level. There is always a possibility that a youngster may get the idea that he knows all about the subject instead of the correct impression that he has been through an exploratory experience. I know from personal experience that for the talented boy or girl the highschool years can be frustrating because of the slow pace of learning. Fortunately there now are many advanced instruction programs in secondary schools all over the country. The success these graduates enjoy in college is graphic testimony that we have neglected the unusual student in the past. It is because of this that our institute feels it has a duty to provide the more-than-curious science student with opportunity to explore the vastly widening scientific areas so that he will have a familiarity on which to build knowledge. Let's face it. You can't keep youngsters away from a topic in which they have a deep interest."

Robert W Neathery
Director, Science Museum
The Franklin Institute
(Where highschool students are taking after-hours courses in highly advanced subjects, such as radioisotopes)

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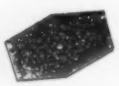
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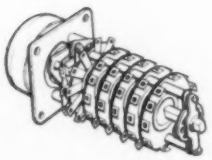
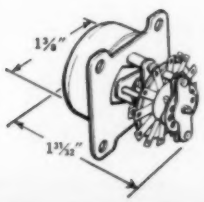
Ledex Rotary Selector Switch

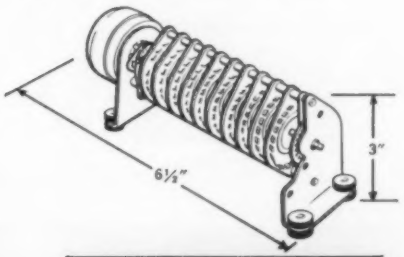
BASIC INFORMATION



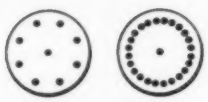
Functions as a power operated remote control circuit selector or stepping switch.



Smallest switch is size 2E with 1 to 4 switch wafers.



Largest standard switch is size 5S with 1 to 10 switch wafers, foot, flange or panel mounting.



8 position 24 position

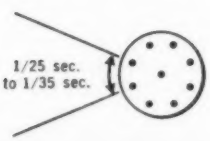
Switch wafers available with 8, 10, 12, 16, 20 or 24 positions.

1 circuit, 12 positions

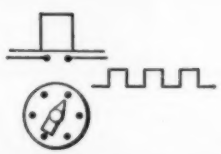
3 circuits, 4 positions each

Circuitry of wafers is flexible. For example 12 position wafer can be one circuit with 12 positions or 3 circuits with 4 positions each.

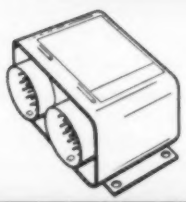
Will self-step to any pre-selected position.



Self-stepping speed is 25 to 35 steps per second depending on number of positions.



Programmed, manual rotary switch, or pulse controlled.



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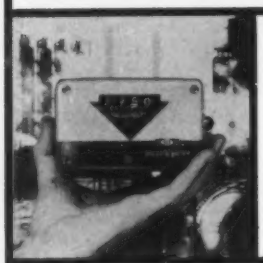

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READER TO EDITOR

Sketches by Scheffy

To the Editor:

I have noticed that in the last few issues of PRODUCT ENGINEERING you have deleted the engineering sketches by Scheffy. These were very funny and worthwhile. Why not get them back?

—E. H. LENZ
Product engineer
Buffalo Forge Co

• The cartoons by Mr Scheffy and his compatriots are a very favorite part of our content, but sometimes they are forced out of an issue by mechanical considerations.—Ed.

Automobile Safety Problem

To the Editor:

Karl M. Richards of the Automobile Manufacturers' Association states in "Points of View" for Feb 13, p 20, that the auto industry objects to regulatory documents that specify design (engineering specifications). Instead, he asks for specification of performance (what the equipment should do).

His reasoning is that this specification of function would not restrict development by forcing on the engineer outmoded and inflexible codes.

It has been said that people generally have at least two reasons for saying something: a good reason, and the real reason. This sounds like a good reason for opposing restrictive legislation, but before we can believe that this is a real reason, we need more proof.

Mr Richards could supply such proof quite simply in the case of seat belts. If the industry opposes mandatory seat belts because such legislation might restrict later (presumably better) solutions to the problem of post-impact injury, how would the industry react to legislation requiring all cars to be supplied with some means of providing the same protection as that afforded by seat belts? This definitely is a performance, not a design, requirement. And I'm sure that Cornell's Crash Injury Research group could supply the necessary specifications.

—W S CRAWFORD
Kamloops, BC, Canada

To the Editor:

Your article in the Feb 13 issue (p 24) did nothing more than rehash the views of medical people and do-gooders. In the accompanying "Points of View" (p 20) you allowed the industry to speak its piece on auto safety and got a polite reply, but no meat. When will you people and the majority of "safety experts" take a look at it from the industry's viewpoint?

The automobile industry is not a charitable organization. To paraphase an old advertising slogan, "They are automobile men, not medicine men." They are in business to make and sell cars, not to save lives. Obviously if they could make a

safer car that would sell better than their competitor's, they would.

But try to understand that every company is in a competitive war with every other car manufacturer here and abroad. They have to cut costs in order to maintain a competitive advantage. Do you realize that if General Motors spent $3 to equip every new Chevrolet with a seat belt, the total cost would be in excess of $5 million? Sure General Motors could afford it, but why should they sacrifice their competitive position to Ford when the consumer can just as easily pay a few bucks out of his pocket. You will say this is a cold-blooded approach. No, auto people are businessmen. Show me one industry that will sacrifice profits to give the consumer something he doesn't want. General Motors has a saying, "A penny saved is $10,000 earned" (one cent times one million cars equals $10,000). Next time you get on a safety kick, try to appreciate both sides of the situation.

—Brace Lewis
Brooklyn, NY

COMING EVENTS

MARCH

12-16 . . . . American Society of Mechanical Engineers; Aviation Conference, Statler Hotel, Los Angeles

14-16 . . . . Society of Automotive Engineers, National Automotive Meeting, Sheraton-Cadillac Hotel, Detroit

20-23 . . . . Institute of Radio Engineers, International Convention, Waldorf-Astoria Hotel & NY Coliseum, NYC

20-24 . . . . American Society for Metals, 12th Western Metal Congress & Exposition, Ambassador Hotel & Pan-Pacific Auditorium, Los Angeles

27-31 . . . . Instrument Society of America, National Bureau of Standards, American Institute of Physics, Temperature Measurement and Control, Veterans Memorial Building, Columbus, Ohio

APRIL

4-7 . . . . Society of Automotive Engineers, National Aeronautic Meeting and Missiles and Aircraft Engineering Display, Commodore Hotel, New York

5-7 . . . . Institute of Environmental Sciences, Annual Meeting and Equipment Exposition, Sheraton Park Hotel, Washington, DC

11-13 . . . . American Society of Lubrication Engineers, Annual Meeting and Exhibit, Bellevue-Stratford Hotel, Philadelphia

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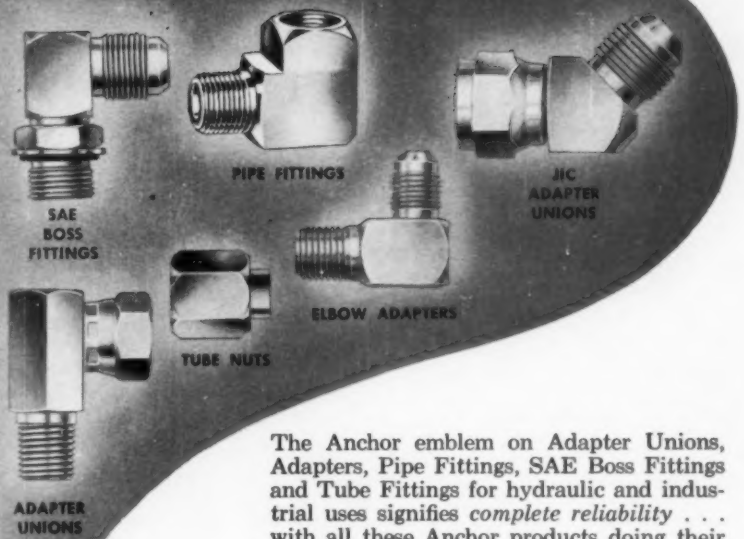

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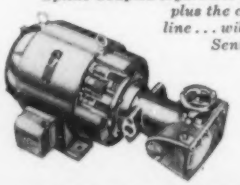
*Exclusive, new intermediate ratings.

Your copy of this catalog on Reuland Spline Coupled Hydraulic Pump Motors... plus the complete Reuland line... will come in handy. Sent free on request.



REULAND MOTORS

REULAND ELECTRIC COMPANY
Western Division: Alhambra, California
Eastern Division: Howell, Michigan
Distributors in all principal cities

CIRCLE 30 ON READER SERVICE CARD

CIRCLE 31 ON READER SERVICE CARD→

see how Caplugs protect products . . . send for this FREE sample kit

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2205-9 Elmwood Ave., Buffalo 23, N. Y.

MAIL a free assortment of Caplugs, literature and prices to us, without obligation.

Name_____

Title_____

Firm_____

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City_____ Zone____ State_____

won't chip, break, shred, or collapse

low cost product insurance

easy to apply . . . and remove

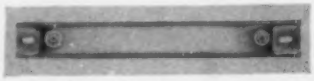
molded of tough, flexible Polyethylene

Caplugs

Quick, slick protection for tubing, threaded fittings and machined parts in process, storage and transit . . . more than 600 sizes now in stock.

Versatility

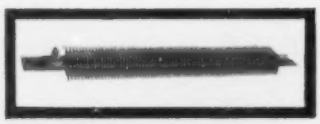
IN VULCAN STRIP HEATERS



Vulcan Strip Heaters have almost unlimited application for heating any smooth, dry surface to which they can be bolted or clamped — dies, platens, molds, etc. They can also be mounted for comfort and process air heating applications.

BAND HEATERS

Latest development in the Vulcan heating line, Band Heaters are especially applicable for plastic molding and extruding machines, tanks, pipelines, autoclaves, and similar uses. An aluminized steel sheath, together with a special alloy tight-gripping clamping band, assures long life. Wide range of diameters.



FINNED HEATERS

Finned heaters provide six times more effective heat transfer surface than standard strip heaters for air duct heating, blowers, unit convection heaters, etc.

Send for Catalog VG-201 containing specifications and prices.

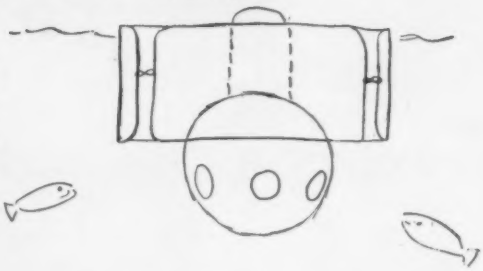
VULCAN

Versatility in Electric Heating

VULCAN ELECTRIC COMPANY, Danvers, Mass.

FOR YOUR INFORMATION (personal)

Down to the sea with props



Want to design an underwater helicopter? The field's wide open. Jacques Piccard, young member of the famous explorer family, is in this country to raise money for a "mesocaph"—a propeller-powered bathysphere. Right now, it's still in the idea stage, but he believes something along the lines of this "blueprint" would be practical.

At an interview following his acceptance of the Argosy "Giant of Adventure" award, he noted that a powered sphere would have much more maneuverability and a higher instrument payload than present ballast-operated units. All that's needed now is an engineering design—and half a million dollars.

How to foil a felon

It's a tough life for locks these days. Not only can they be jimmied and blown apart; their secret combinations can be exposed by X-rays from readily portable isotope sources.

There's help on the way, though, from inventors here and abroad. Two Naval Ordnance Lab engineers have developed and patented a radiograph-proof combination lock; and the British have one that's "explosion proof."

The US invention is a combination lock that uses nylon tumblers instead of metal (they show up much less clearly on X-rays) and, in addition, provides two X-ray shields in front of the lock—one, a layer of lead that will absorb the rays, and the other a layer that scatters the rays. This second layer can be a perforated steel sheet, or, better still, a layer of molded plastic incorporating small steel balls. With this system, says E. L. Criscuolo and D. P. Case, any X-ray picture will turn out to be hash.

The British device, an "anti-explosive lock," is specifically designed to prevent trouble after the lock is blown—to get around the time lag (owing to disuse and corrosion) that may permit the door to be opened before conventional anti-explosive bolts can move into position. The new system, as described by Britain's National Research & Development Corp, completely immobilizes the bolt, when the lock is blown. It involves a lever-and-cam mechanism, which connects bolt and handle under normal conditions, but disconnects immediately when the lock is blown. Full information and diagrams of the lock (7943-60) may be obtained from NRDC's U.S. office: Suite 503, Mercury Building, Washington, DC.

For better mike-manship

A microphone that can be adjusted to provide either the wide-band flat response needed for music reproduction, or the peaked response curve that is best for voice reproduction, is offered in a do-it-yourself kit by CBS Electronics. Price: $7.50.

It features a ceramic transducer and a stainless steel case, has a sensitivity at 1000 cps of 52 db below 1 volt/microbar and a frequency response range of 30 to 10,000 cps. "Adjustment" is by insertion of a screw in a hole drilled in housing. —ARG

CIRCLE 33 ON READER SERVICE CARD →

IMAGINATION TAKES SHAPE & COLOR

Imagination takes shape, color—*and reality*—in the myriad forms, finishes and textures Monarch imparts to durable cast aluminum. With porcelain enamel, for instance, great vistas of color and new product possibilities spread before the designer. Monarch research and development engineers are creating unique uses for versatile cast aluminum...for industry, for products for the home, for unmatched lifetime beauty and performance. They'd be glad to work with you on new ideas for manufacturing products of *your* dreams.

Write R. A. Lawson, Vice President of Marketing, for Monarch's full-color "idea book" illustrating some of the unusual applications of cast aluminum in a variety of finishes. No obligation.

MONARCH ALUMINUM MFG. COMPANY

9205 DETROIT AVENUE • CLEVELAND 2, OHIO

MANUFACTURING ACHIEVEMENTS IN MOLTEN ALUMINUM

At Eastman you can find plastics to shape a new world of products

Ideally suited to modern high-speed vacuum-forming techniques, Tenite plastics are cutting costs sharply for many manufacturers

Vacuum forming—one of the oldest techniques of fabricating plastics, but only in recent years adapted to speedy modern methods—is now in the foreground of interest as an important method of shaping plastics products for today's market.

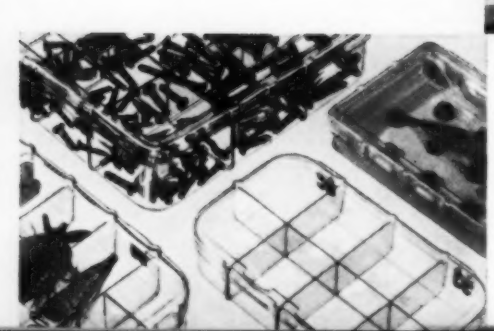
Starting material for a vacuum-forming operation is an extruded thermoplastic sheet. In simplest terms, vacuum forming involves only two steps, both performed on the same machine. The first step consists of clamping the flat sheet of plastic in a frame above the waiting mold and heating it (with built-in heaters) to the required forming temperature. In the second step, the heated sheet is brought down into close contact with the mold, suction is applied, and atmospheric pressure then forces the heat-softened sheet over and into the contours of the mold.

Sheet extruded from any of the Tenite plastics is well-suited to vacuum forming. Typical commercial products made of these plastics are shown on these pages. They illustrate the diverse shapes and uses to which vacuum forming can be adapted. An outstanding advantage of the Tenite cellulosics—Tenite Butyrate, Tenite Propionate and Tenite Acetate—is their low specific heat which speeds both heating and cooling. Sheet of these plastics can be formed quickly and economically into tough, lightweight, highly impact-resistant products of enduring luster.

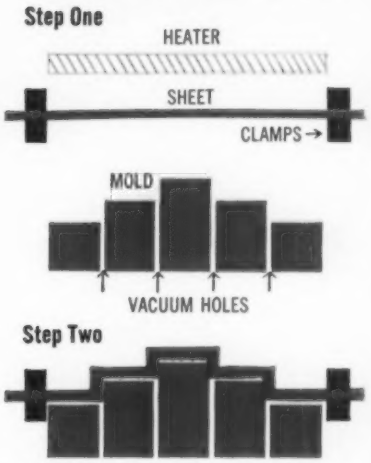
For products that are to be used outdoors, special formulations of Tenite Butyrate are available which provide excellent weather resistance and dimensional stability.

Tenite Polyethylene and Tenite Polypropylene are other Eastman plastics useful in vacuum forming. While slower to heat and cool than sheet of the cellulosics, these can be more satisfactorily formed in molds with sharp angles and offer many physical and chemical properties useful in housewares, industrial products, toys and packaging.

All Tenite plastics are available in a virtually unlimited range of colors. Over the years, the Tenite Color Laboratory has developed formulations in almost 43,000 different colors and color effects. For many applications, colored sheet can be used to yield an integrally colored product, eliminating the need for a separate decorating or painting operation. In other applica-



HOW VACUUM FORMING WORKS



NOTE: The above diagrams depict a simple vacuum-forming operation. There are many variations of this method, including some in which air pressure or mechanical pressure replaces the use of a vacuum.

tions, such as signs, clear-transparent sheet may be used, with the decoration being applied either before forming (by use of distortion printing) or after forming. It should be noted that even shapes which at first appear impossible to vacuum form can be produced by this method. For example, by using a "plug-assist" (to permit a deep draw), wastebaskets 8½" in diameter and 11½" deep have been vacuum formed from sheet of Tenite Butyrate. Similarly, spherical globes for toys and outdoor lanterns have been produced at low cost by vacuum forming two hemispheres and then solvent-cementing them together.

An important advantage of vacuum forming is the low cost of the necessary molds... often only 1/20th to 1/10th as much as those for injection molding. As a matter of fact, very inexpensive molds can be cast from plaster or tooled from hardwood or pressed wood to use on test runs, developmental designs, or single or short-run production.

The obvious economies inherent in vacuum forming have helped the technique win quick favor in many fields. In the manufacture of outdoor signs, displays, toys, housewares, decorative and lighting panels, vacuum forming is now a leading production method.

Vacuum forming also makes possible the rapid packaging of merchandise in bubble, blister or skin packs. Here, short heating and cooling cycles are particularly important because of the high speeds at which the packaging machines operate.

Perhaps vacuum forming with Tenite plastics could help you cut costs or speed production of some item you are now making or planning to make in the future. We'll be glad to help you explore its advantages and evaluate its merit.

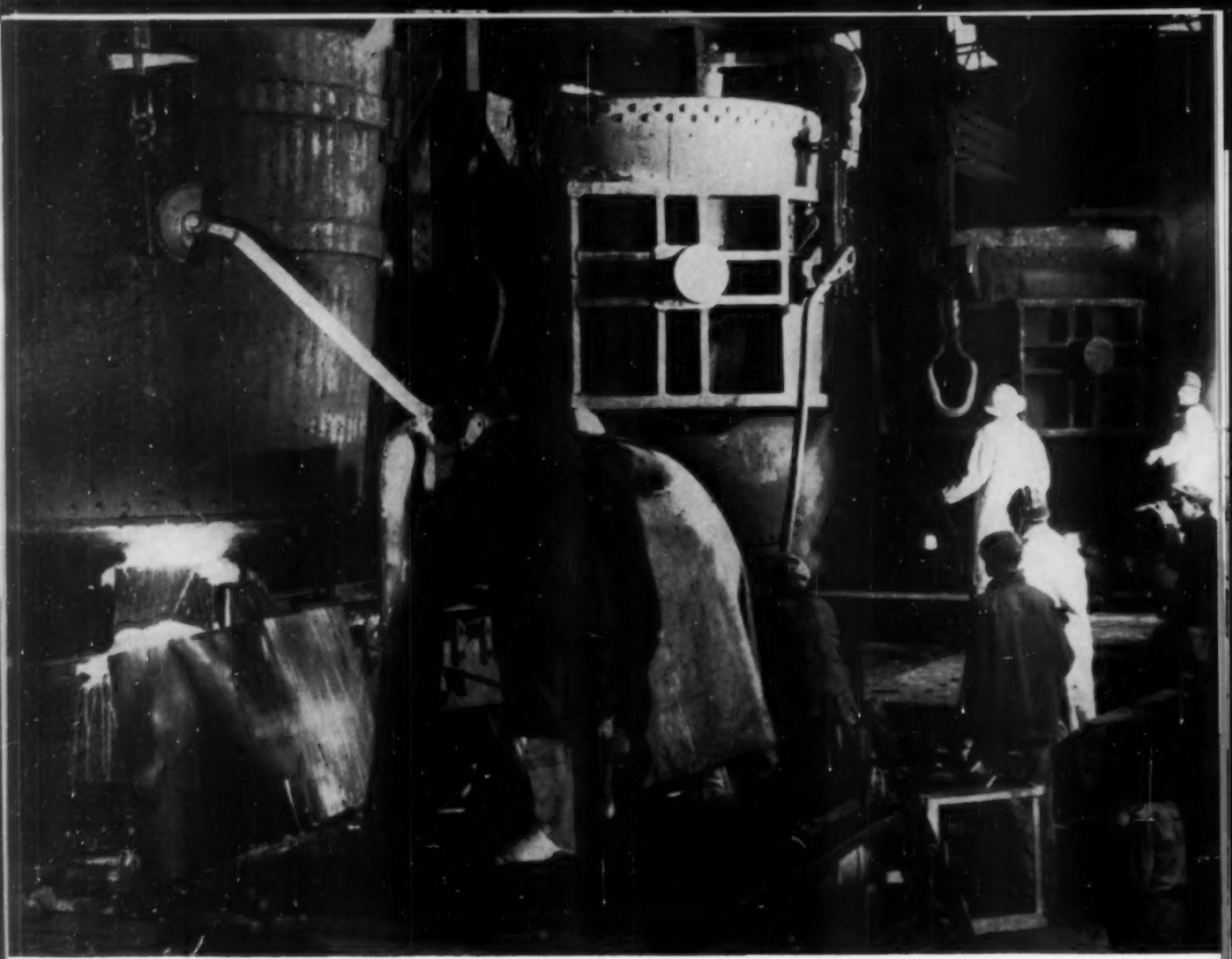
The comprehensive story of how Tenite plastics are being used in this new manufacturing process is told in a 20-page booklet, "VACUUM FORMING." For your free copy, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENN.

TENITE®

BUTYRATE • PROPIONATE • ACETATE
POLYETHYLENE • POLYPROPYLENE

Versatile plastics by Eastman

CIRCLE 35 ON READER SERVICE CARD



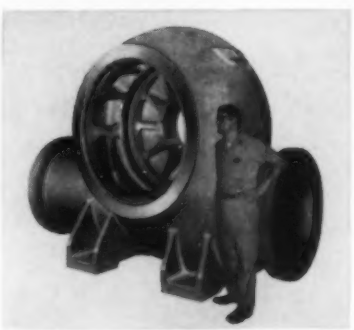
Specification steel making in Blaw-Knox Steel Foundries gives your product physical properties for maximum service

To insure the physical properties necessary for the service requirements of your product, Blaw-Knox maintains facilities for specification steelmaking including the regularly used mixes of carbon steels as well as special alloys such as molybdenum, chrome, nickel, and vanadium grades.

Ten acid open hearths, ranging in capacity from 10 to 70 tons, and two electric furnaces are available to produce exact quantities of many different grades of steel for many different castings at the same time. In some cases, as shown, huge castings weighing up to 300,000 pounds are poured simultaneously from three ladles.

Steelmaking to your order, in large or small amounts, is another part of Blaw-Knox Steel Casting Service that adds value to your product. And there's good reason why. Blaw-Knox, one of the world's leading manufacturers of rolling mills and industrial machines, knows how to keep an eye on the end-use conditions of a steel casting, make it for maximum service.

If you design or build products using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Castings Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.



This intricate pipe line booster compressor housing was cast and machined at a Blaw-Knox Foundry. Test pressure 1800 p.s.i.—working pressure—1500 p.s.i. Weight—20,000 pounds.

BLAW-KNOX

Steel Castings

CIRCLE 36 ON READER SERVICE CARD

Solve Multi-Point Temperature Control Problems...

at ⅔ cost of competitive systems

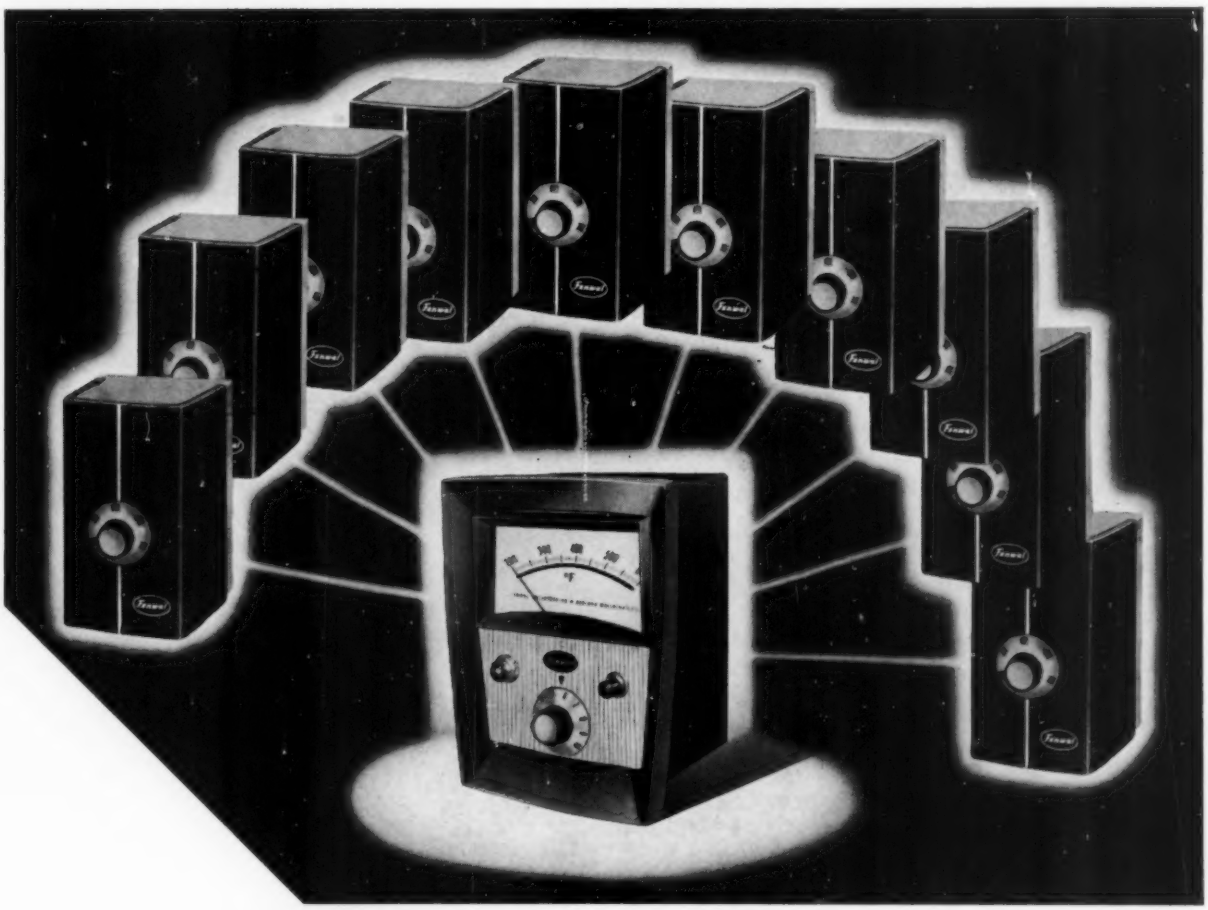
You get them all — wide ranging versatility . . . maximum sensitivity . . . easy installation and servicing! These features *combine* in a Fenwal 536-580 multi-point monitoring system to give you precise, transistorized temperature control and indication. And *you choose the features you need to suit your own requirements!*

Examine these cost saving advantages: Indication and control circuits are separate . . . the 536-580 system eliminates the need for separate indication and control at each point. You can build a control system concurrent with your needs — start with 2 points and build up to 10 points without paying a premium at the outset. The complete control system is built from *standard* catalog parts, thereby eliminating the need to buy costly "specials" for servicing at a later date.

Individual points can have either proportioning or ON/OFF control modes. The system permits "flick of switch" indication of from 2 to 10 temperatures. Individual set points can be adjusted from a central control panel or through a separate potentiometer remotely located. You select your own number of points and you *pay only for the options you use.*

Choose from five standard temperature ranges — from −50 to 600°F . . . expanded scales permit fine temperature adjustments and improved readability, and *the entire system gives you sensitivity to within 0.1°F.*

Both instruments are smartly styled to perfectly complement modern industrial machines and interiors. A Fenwal engineer will be glad to supply information on this system, or any other temperature control in Fenwal's broad line. Write Fenwal Incorporated, 23 Pleasant Street, Ashland, Mass.



Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

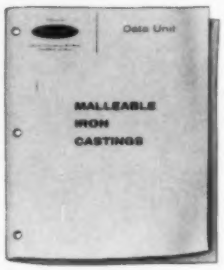
CIRCLE 37 ON READER SERVICE CARD

New Cars and Trucks Use More Malleable For Better Performance...Lower Cost

As the automotive industry steps up its drive to pack greater performance into lighter weight vehicles and still hold costs in line, the demand for Malleable iron castings continues to increase. Noted for their strength, toughness, machinability and economy, Malleables are used as key components in every make and type of vehicle.

Matching each new advance in automotive technology, Malleable is now available in a broad range of properties, including tensile strengths from 50,000 to 120,000 psi!

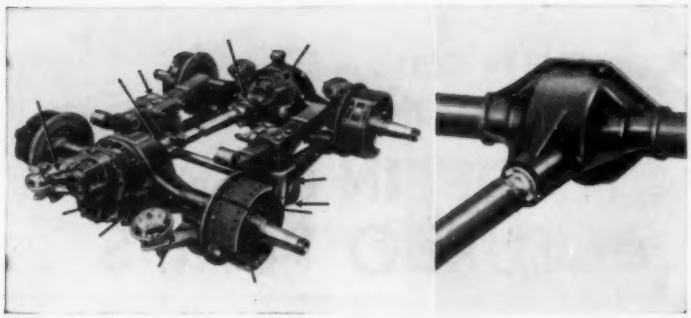
Find out now how much Malleable castings can improve your products. Contact any company that displays this symbol —



For Free Literature on advantages of Malleable iron castings, with examples from the automotive industry, ask any member company for Data Unit No. 113, or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

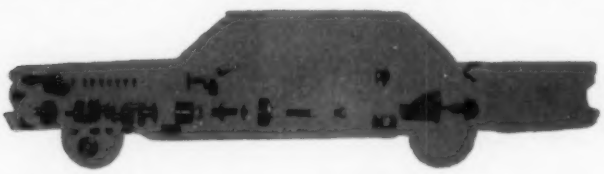
MEMBER
MALLEABLE
CASTINGS COUNCIL

Testifying to Malleable's outstanding ability, pearlitic Malleable iron crankshafts are now used in both cars and trucks, like this new heavy-duty highway hauler. Pearlitic Malleable was chosen for its high strength, wear resistance, damping capacity and machinability . . . Malleable is the most machinable of all ferrous metals of similar properties.



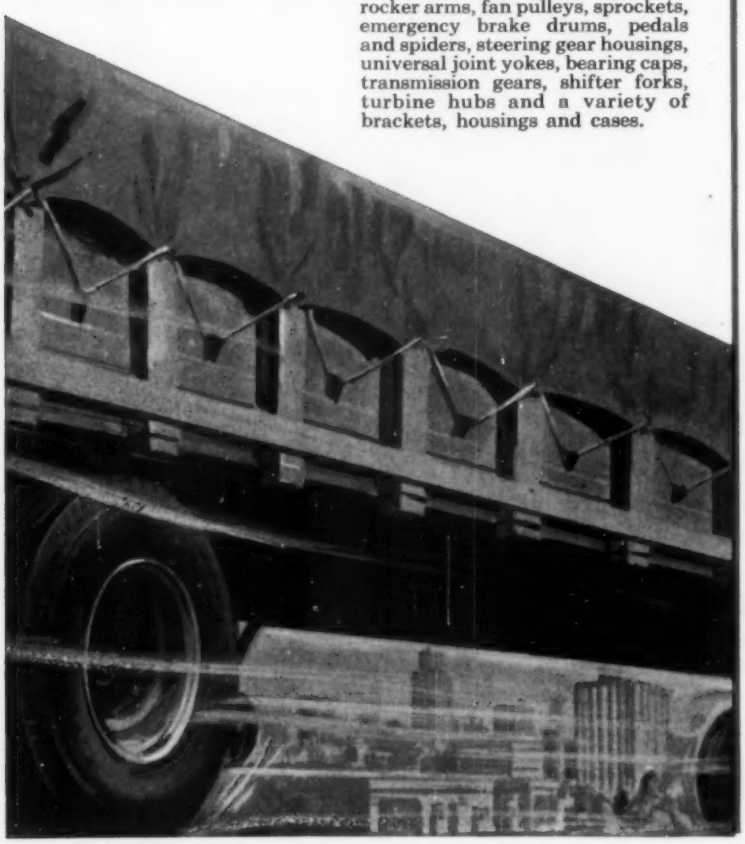
From the smallest cars to the largest trucks, all American vehicles rely on Malleable for a range of uses. In this tandem axle, for example, a total of 36 parts is Malleable.

Malleable differential carriers form the backbone of the rear axles on many new compact cars, as shown at the right above. Tubular steel extensions are pressed into the Malleable housing where they are "puddle" welded. Decisive factors in Malleable's selection were strength, economy, ease of machining and ability to be produced in a design that required a minimum of tooling expense.



The increasing conversion from other materials to Malleable castings for all kinds of parts from crankshafts to door hinges is adding momentum to the automotive industry's steadily increasing use of Malleable.

Among the many Malleable iron castings in this composite car are torsion bar arms and brackets, rocker arms, fan pulleys, sprockets, emergency brake drums, pedals and spiders, steering gear housings, universal joint yokes, bearing caps, transmission gears, shifter forks, turbine hubs and a variety of brackets, housings and cases.



For Quality and Economy Use

MALLEABLE

For Service Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Iron Works, Moline
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Mall. and Steel Castings Co., Cleveland 5

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

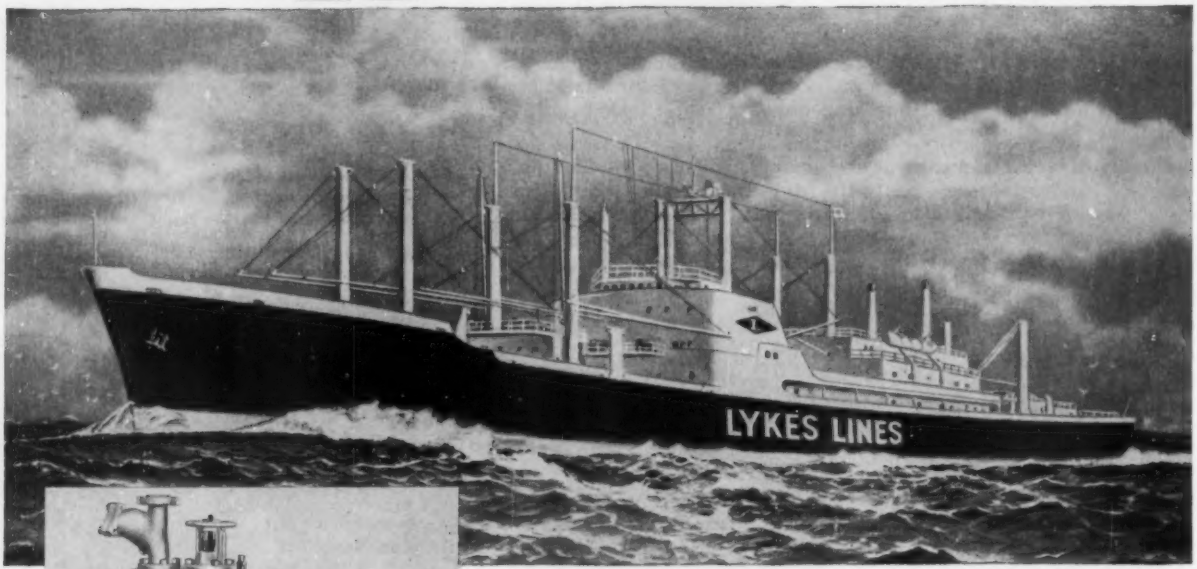
TEXAS
Texas Foundries, Inc., Lufkin

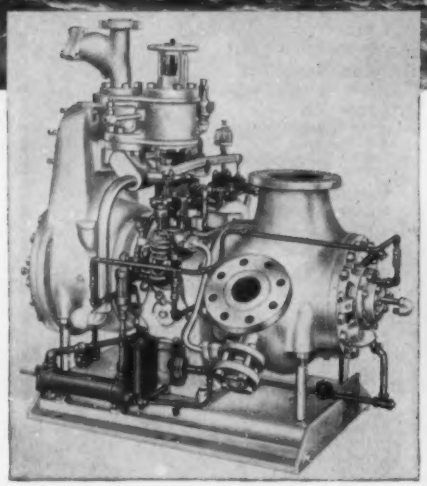
WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

These companies are members of the Malleable Castings Council

MARLIN-ROCKWELL RELIABILITY COUNTS *in* **COFFIN** *boiler feed* TURBO PUMPS





The fast, new Lykes Cargo Liners ply the Atlantic in coastwise shipping.

Boiler Feed Services for these 494 foot vessels are provided by Coffin Turbo Pumps equipped with MRC Precision Ball and Roller Bearings.

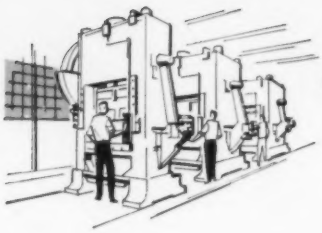
MRC Ball and Roller Bearings are used in a variety of marine applications. MRC engineers, with 63 years background of bearing knowledge, are prepared to discuss your bearing problems with you.

MRC pioneered, developed and produces the Super-Precision Ball and Roller Bearings, shown here, for high temperature, high speed and to provide the ultimate in accuracy and load carrying capacity.

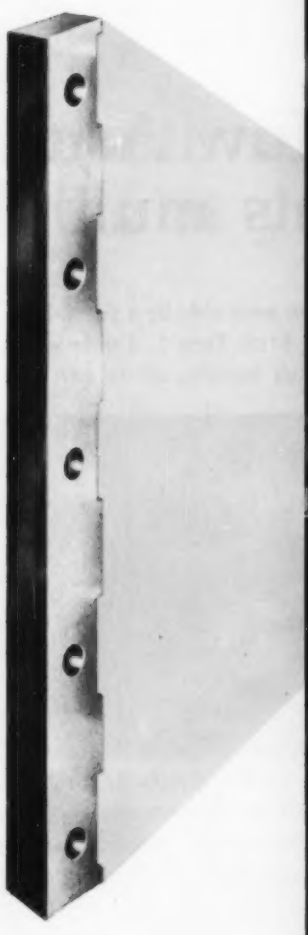
MRC
BALL AND ROLLER *bearings*

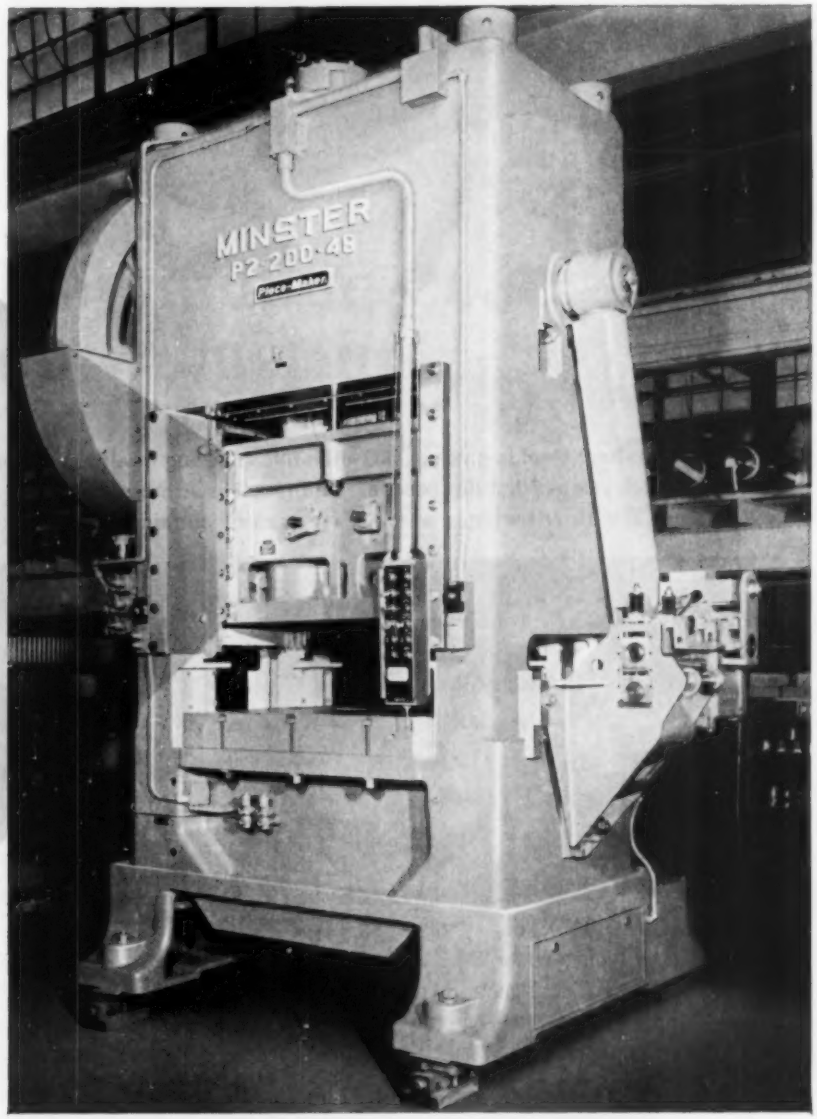
MARLIN-ROCKWELL CORPORATION

Executive Offices: **Jamestown, N. Y.**



ANOTHER SATISFIED USER





LAMINA-BRONZE WEAR PLATES

Lamina
DIES AND TOOLS, INC.
P.O. BOX 31 ROYAL OAK, MICHIGAN
Phone JOrdan 4-8711

Lamina-Bronze Wear Plates and their use are more completely described in Bulletin WP-59, send for your free copy.

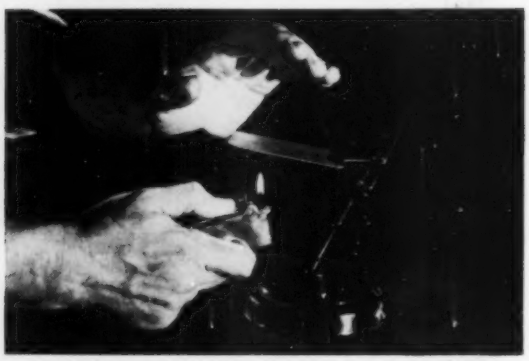
The adjustable slide ways of this Minster press utilize Lamina-Bronze (electroplated bronze on steel) Wear Plates to assure long-life and free-running. In like manner, Lamina-Bronze wear surfaces are the best answer for any part that requires the non-seizing properties of bronze and the strength of steel.

CIRCLE 41 ON READER SERVICE CARD 41

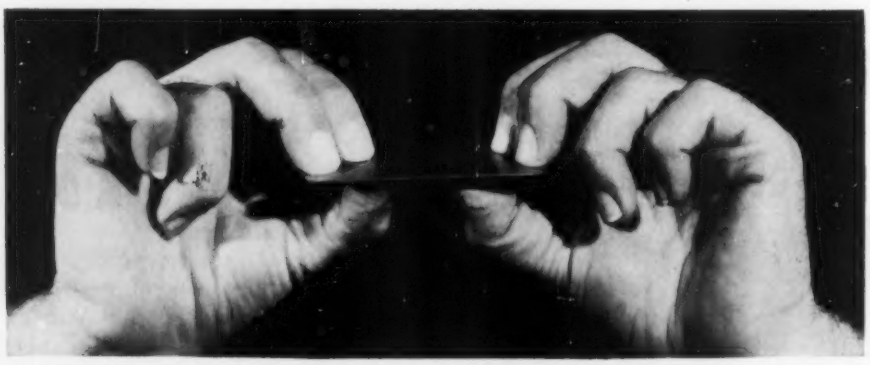
How Armco puts multiple

Strong sheet steel is given a .001-inch thick coating of aluminum on each side by a special Armco-developed hot-dip process. The result is Armco ALUMINIZED STEEL Type 1, a unique material with advantages of steel, features of aluminum, and bonus benefits all its own.

RESISTS HEAT AND CORROSION—ALUMINIZED STEEL Type 1 withstands temperatures up to 900 F without discoloration, to 1250 F without destructive scaling. It also resists corrosive condensates that form on cooling. Real advantages in mufflers, furnaces and similar products.



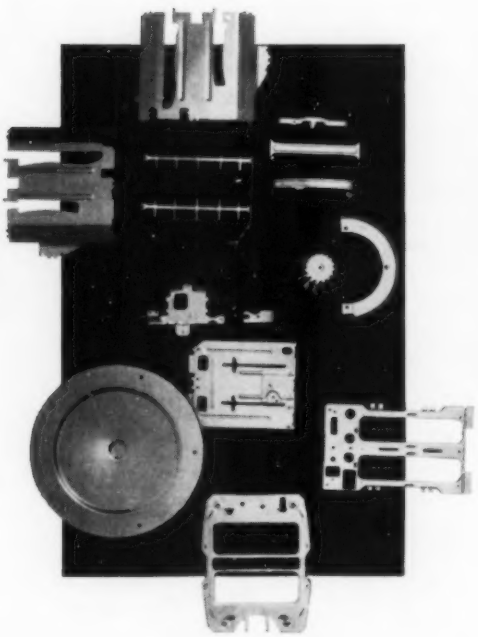
REFLECTS HEAT—To 900 F, ALUMINIZED STEEL reflects up to 80% of radiant heat, helps direct heat where you want it, cuts down heat loss. Hundreds of parts for large and small appliances are now proving the practical benefits of this heat reflectivity.



STAYS STRONG—Parts that resist or reflect heat can double as structural sections when made from Armco ALUMINIZED STEEL because it keeps its strength at high temperatures. This also permits thinner, more economical gages than with metals that weaken under heat.

New steels are born at Armco

Steel with an aluminum coating benefits at your fingertips



TAKES FABRICATION—Armco ALUMINIZED STEEL Type 1 withstands moderate forming, drawing and spinning operations without flaking or peeling of the coating or damage to base metal. This workability, coupled with its other outstanding properties, accounts for its successful use in a growing number of industrial, commercial, and consumer products.

Use this label to tell customers your products are made from modern, dependable steel.

SEND MORE DATA

Armco Division
Armco Steel Corporation
1291 Curtis Street, Middletown, Ohio

Please send further facts on Armco ALUMINIZED STEEL Type 1.

Name _____ Title _____

Firm _____

Street _____

City _____ Zone _____ State _____

ARMCO **Armco Division**

Are your "dead storage" files more efficient than your active drafting files?

No doubt about it—it's important to keep correspondence carefully filed; *but* it is even more important to equip your drafting department with modern filing facilities that keep active and semi-active drawings readily accessible, fully protected—and in a minimum of space.

Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment—from Dietzgen

Inadequate or antiquated equipment in your drafting room *can cost you more money* than you imagine in lost time, errors, done-over work, and low morale. Hamilton equipment is *engineered* to fit your needs. It is *designed* to improve the practical, day-to-day creativity of your engineers or draftsmen. Its performance has been tested and *proved* in many thousands of installations. Our designers will gladly assist in the planning of your department. No obligation, of course.

HAMILTON UNIT SYSTEM FILES The Hamilton system offers maximum protection and capacity in minimum floor space. Each drawer of the patented shallow drawer units is equipped with a tracing lifting mechanism. Every tracing becomes a top sheet, instantly accessible. Unit sections can be assembled in a number of arrangements, stacked safely to any practical height. They stand up to hard usage, perform perfectly year after year.

Hamilton L-Contour Table
Prestige-assured, individualized work area providing complete board adjustment plus extra storage and reference area.

Hamilton CL 100 Drafting Table
Conserves dollars, yet rugged canted-leg design provides modern styling and convenience with long-term durability.

Hamilton Auto-Shift Table
Built-in mechanism adjusts board to individual height and slope requirements, provides full accessibility, reduces errors.

Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems

This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-A10.
Eugene Dietzgen Co., Chicago 14, Illinois

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EVERYTHING FOR DRAFTING
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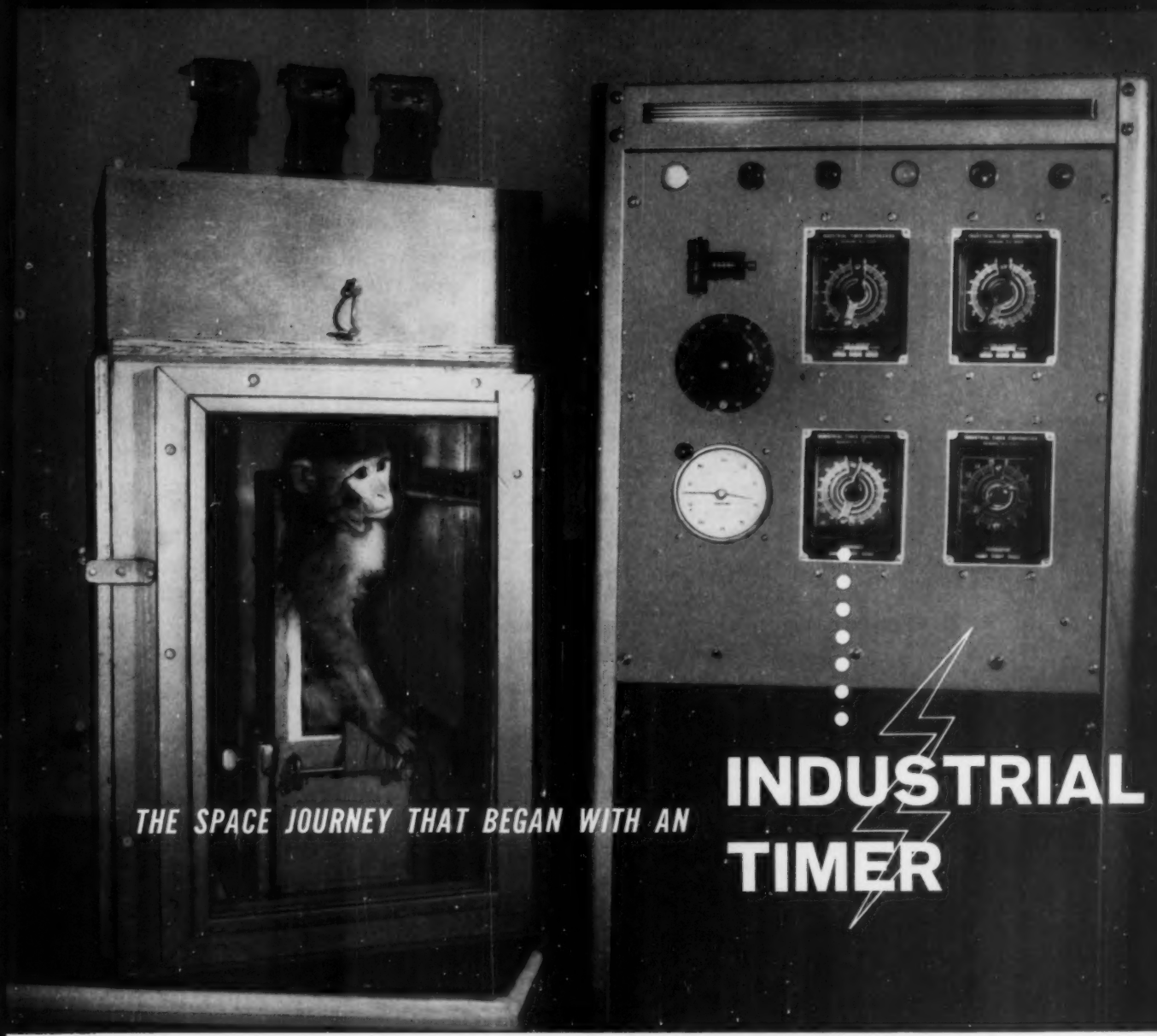
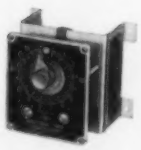
CIRCLE 45 ON READER SERVICE CARD→



THE SPACE JOURNEY THAT BEGAN WITH AN

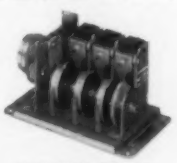
INDUSTRIAL TIMER

INTERVAL TIMERS



TIME DELAY TIMERS

RUNNING TIME METERS



RECYCLING TIMERS

The first space shot with living creatures that returned alive is now history—a significant milestone in the conquest of space.

The two monkeys, placed aboard the rockets to help scientists gather data on the probable effects of space travel on man, received unique training on the apparatus pictured above.

They were conditioned to manipulate the lever in response to timed stimuli, governed by a 4-unit tandem of Interval Timers by Industrial Timer Corporation.

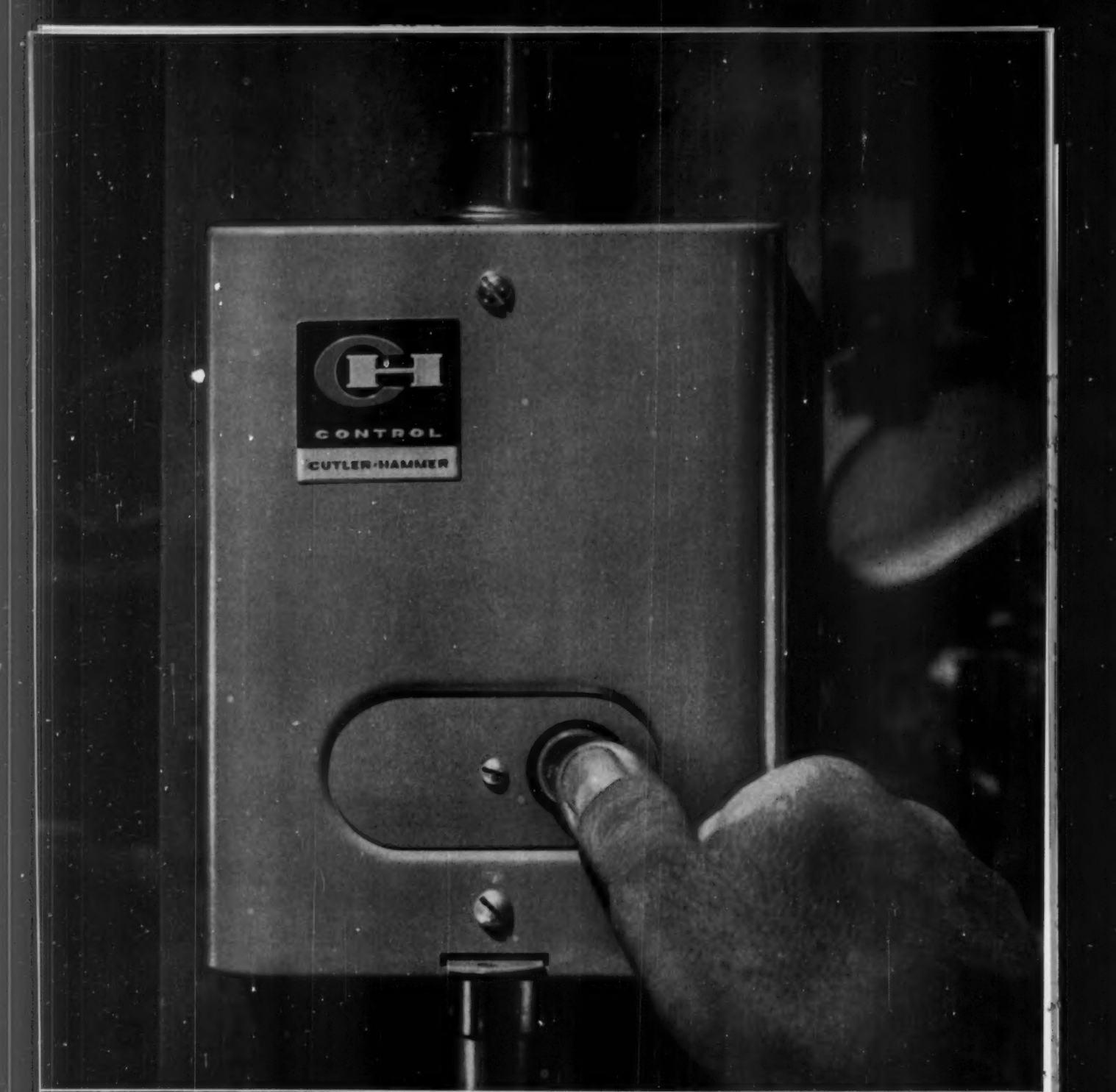
This is not the first time our products have been used in medical and psychological projects. However, they are more commonly found where precise, reliable timing of industrial processes is vital.

Send for literature describing the comprehensive line of Industrial Timer Corporation Timers for every industrial application.

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION

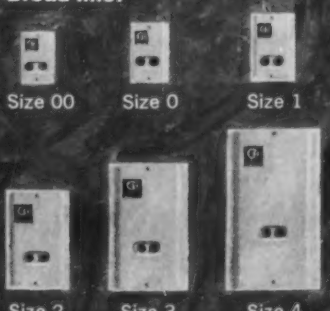
1403 McCarter Highway, Newark 4, New Jersey



Smaller! About 20% smaller than Size 0 Starters. Just 5 3/4" wide, 7" high and 4 3/16" deep.

Convertible! Carried in stock with three cover options or easily converted in field from "reset" only to "start and stop-reset" or "three-position selector switch." Kits at optional cost.

Broad line!



A new addition to the famous three star line

New! Save space and money with Cutler-Hammer's Size 00 A-C Magnetic Starter

Takes up to 20% less space... costs 18% less than Size 0 Starters. Now you get two big new bonuses in control selection . . . less space and less money Both with the all new Size 00 Starter.

Before, you had to use a larger starter in applications where it really wasn't needed. But, now you can use the Size 00 in about 40% of the applications where the Size 0 is usually used.

The new Cutler-Hammer Size 00 Starter performs to the same high standards you get from all Cutler-Hammer Starters. And, you still get vertical, dust-free contacts which add so much to more reliable starter performance. Your choice too, of 2-coil or 3-coil overload protection in the same small enclosure.

The Bulletin 9586 Size 00 Starter can be used on any general application. Its maximum horsepower ratings: Three phase: 208/220 volts, 1½ hp. 440/550 volts, 2 hp. Single phase: 115 volts, ⅓ hp. 230 volts, 1 hp. It's available open or in NEMA 1 enclosure. Send for Pub. LO-40-E249.

Why you get more from Cutler-Hammer. New things are happening at Cutler-Hammer—new, better products, new engineering ideas and talent, new plant capacity. We're on the move. And, we'd like to show you how we could help you in any electrical control problem. Contact the nearest Cutler-Hammer distributor.

WHAT'S NEW? ASK...

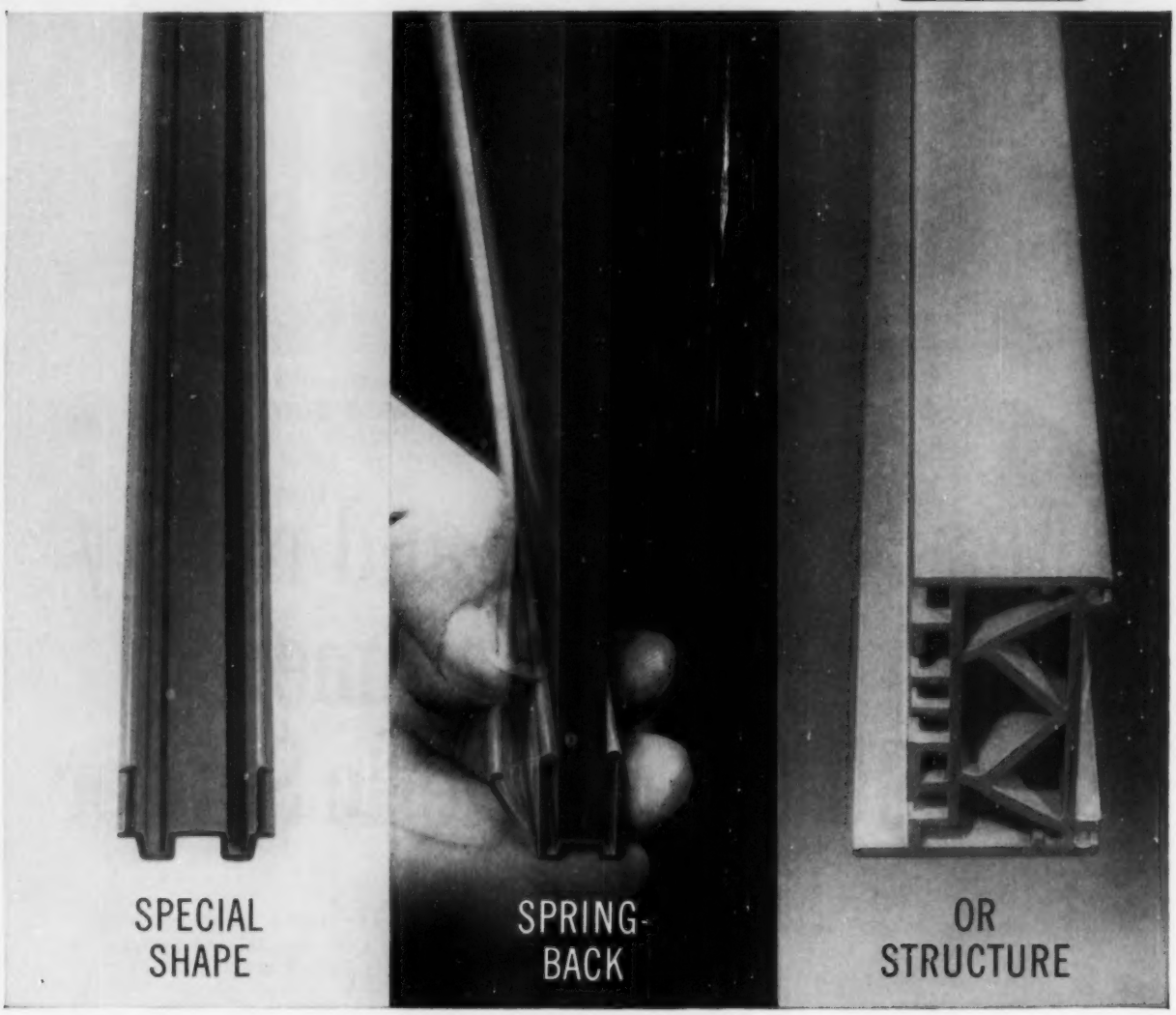
CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A

CIRCLE 47 ON READER SERVICE CARD

Each of these extrusions of rigid Geon by Crane Plastics, Inc., Columbus, Ohio, is in use for various architectural applications—chiefly windows. B. F. Goodrich Chemical Company supplies the rigid Geon vinyl.

B.F.Goodrich



Look how you can solve design problems with extrusions of rigid GEON vinyl

These extrusions show how the properties of rigid Geon lend themselves to solving different design problems. The special shapes show how detail can be reproduced—and it is easy to produce a long, smooth part, *straight* out of the die.

Other extrusions demonstrate how the springiness of thinner-walled extrusions gives you a spring-back characteristic for weather-stripping or rattle-proofing applications. Still others show the structural possibilities—how rigid Geon provides load-carrying strength without weight.

At the same time, each extrusion brings you all the other advantages of vinyl—unusual abrasion resistance, resistance to chemicals, self-extinguishing properties and electrical advantages. In every case there's the opportunity to mold color right in.

How can these extrusions solve your problems? We'd be glad to help you answer this question. Write Department NO-2, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio.
In Canada: Kitchener, Ontario.

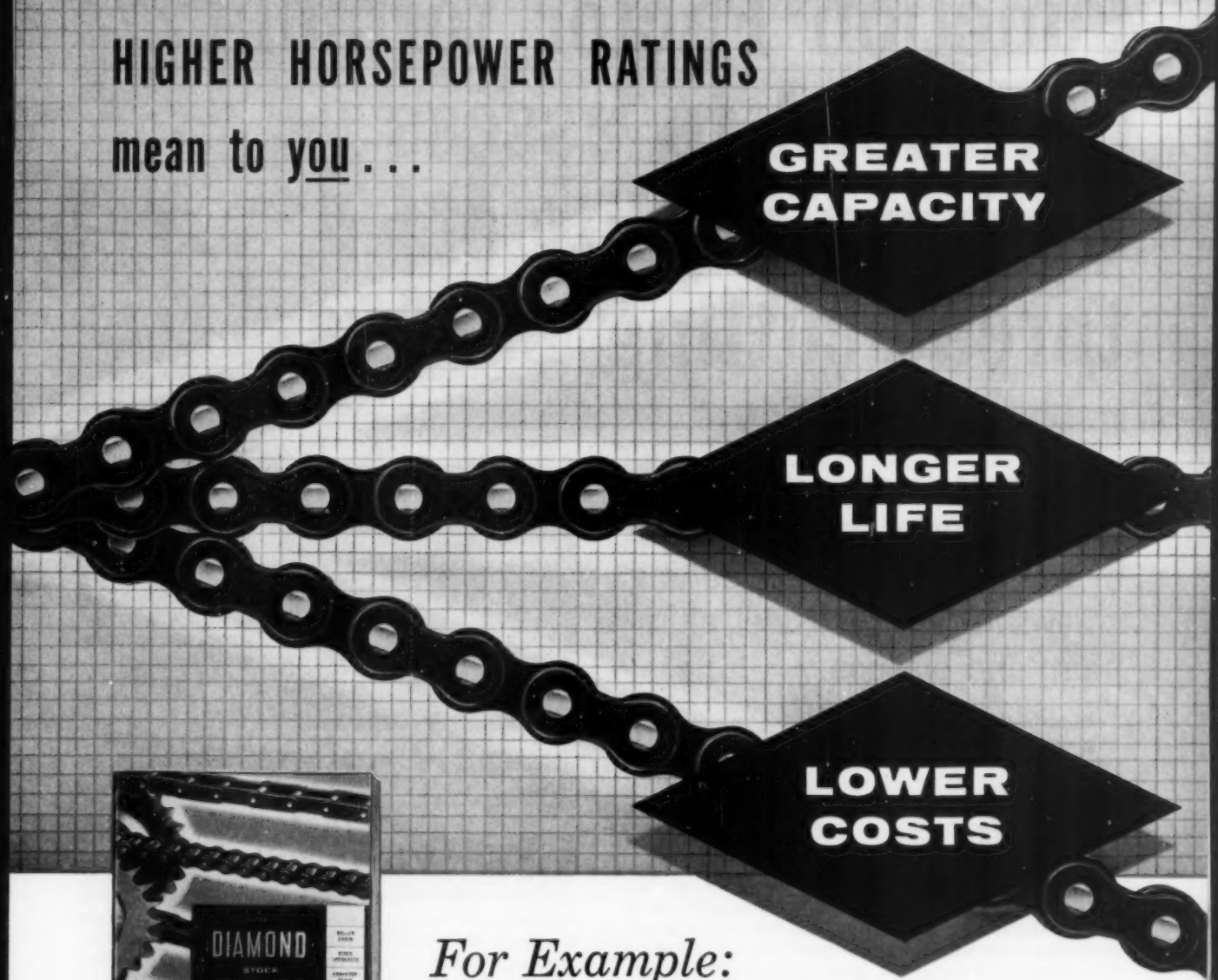
B.F.Goodrich Chemical Company

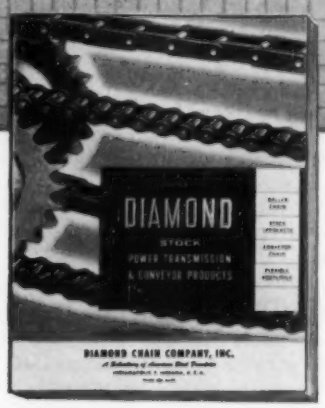
a division of The B.F.Goodrich Company

Geon VINYLS

CIRCLE 49 ON READER SERVICE CARD→

Here's what DIAMOND Roller Chain's HIGHER HORSEPOWER RATINGS mean to you . . .





Write for New DIAMOND CATALOG No. 760

Just off the press. DIAMOND Stock Roller Chain, Sprocket, and Coupling Catalog No. 760 gives all the new horsepower ratings. Catalog 760 also contains full data on four important new DIAMOND Roller Chain Products: *Micropitch*, *Dura-Weld* and *Tuf-Flex* chains and *Hi-Cap* flexible couplings.

For Example:

Former ratings for 1 inch pitch roller chain permitted sprocket speeds up to 1160 RPM, whereas the *new* ratings include speeds up to 2800 RPM. Similarly, rated *horsepower* capacities formerly did not exceed 49 HP, whereas the new ratings exceed 150 HP. New, higher ratings mean that DIAMOND roller chains are capable of more work, will last longer (thus, cost less to operate) than heretofore considered practical. You now have more opportunities to specify high-efficiency DIAMOND Roller Chain drives . . . both in new equipment designs and in modifications of existing equipment. Write today for *new* DIAMOND Catalog No. 760. *It contains all the new ratings* as established by the Association of Roller and Silent Chain Manufacturers, of which DIAMOND is a charter member.

DIAMOND CHAIN COMPANY, INC.
A Subsidiary of American Steel Foundries
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INDIANAPOLIS 7, INDIANA

Offices and Distributors in all Principal Cities

DIAMOND ROLLER CHAINS®

Function Factor formula developed to assess working quality of thread-cutting screws

Unbiased laboratory tests demonstrate superior performance of Parker-Kalon thread-cutting screws in cast iron, steel, aluminum and plastics.

To compare the actual working quality of thread-cutting screws under laboratory conditions, a series of simple yet thoroughly dependable tests were made using P-K Types "F" and "B-F" and competitive thread-cutting screws. These tests can be easily duplicated by any engineering department that would like to determine their own results.

The test was based on the premise that (1) the better a screw resists failure after being driven home, the stronger the assembly, (2) the easier the screw is to drive, the less wear there will be on driving tools and upon the operator and (3) thread failures either on the screw or in the work, gives rise to costly, time-consuming salvage operations as well as other intangible production costs.

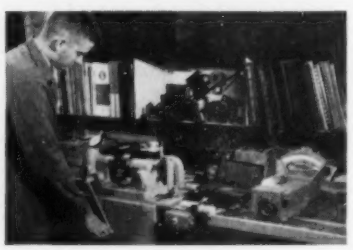
Thus, a measure of evaluating the performance of thread-cutting screws is the ease of driving combined with the degree of resistance to fastener failure. The relationship between these two functions is referred to as "drive-strip ratio."

How the tests were conducted

Random sizes of samples purchased on the open market from a variety of sources (including the P-K Types "F" and "B-F") were identified solely by letters. Manufacturer's names were not revealed to the technicians who were responsible for making the investigation.

As a means of fairly evaluating the performance of the screws, they were applied under identical conditions in sections of cold rolled steel, cast iron, aluminum castings and general purpose plastics. Similarly, hole sizes as well as depth of penetration of the screws were identical.

Each screw was driven by a specially designed Detroit torque testing machine.



To limit and control depth of penetration, washers were placed under the screw heads. Screws were inserted in the hole in the part (steel, cast iron, aluminum, plastic) and the part placed in the jaws of the machine. The screw was driven until it cut a full depth thread. The maximum driving torque was recorded at this point.

Failure Point The second phase of the test was to determine the amont of torque which could be applied to the fastener before (1) the screw failed in section or (2) when the screw failed in the engagement material. This failure point was then recorded in inch-pounds, whereupon a direct comparison of the several screws could be made.

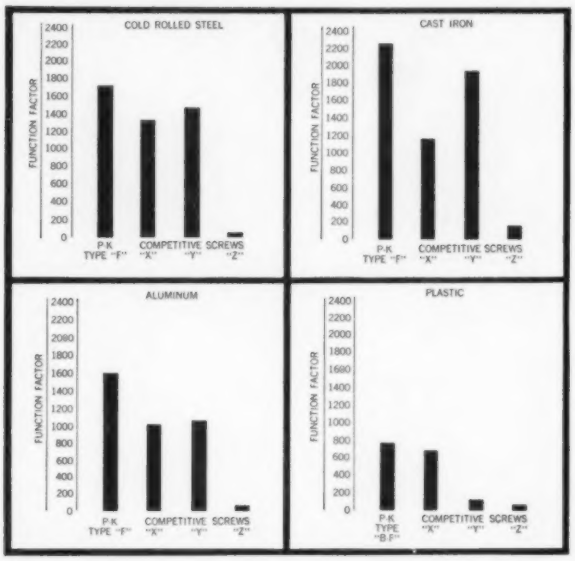
Function Factor In order to assess the working qualities of each screw that was tested, a formula was devised that would express these functions. DRIVE TORQUE was the average of driving torque values obtained from individually running a given number of screws in the application. STRIP TORQUE was the average of a given number of strip torque values obtained from the ultimate failure of the screws in section or of the threads in application.

The formula is expressed as

Formula $$\text{Function Factor} = \frac{(\text{Strip Torque})^2}{\text{Drive Torque}}$$

P-K® thread-cutting screws average 108% better working qualities than the 3 competitive types tested.

Charts shown are typical samples and represent in each case only one of the many tests run on each screw. Identification of screws tested was made only upon completion of test.



Designed to reduce pressure development in the engaging section by as much as 80%, P-K Types "F" and "B-F" thread-cutting screws are manufactured with five cutting flutes. The completely formed threads have sharper cutting edges and flutes are of continuous depth.

Lower Drive Torque

Together these new P-K features make for better clearance of the accumulated material and *assure lower drive torque*. They also sharply reduce the possibility of stripping, galling and other causes of screw failure.

Use Recommendations

P-K TYPE "F"

P-K TYPE F The new, improved P-K Type F (Patented), is a hardened thread-cutting screw developed for use in granular or brittle materials such as ferrous or non-ferrous castings and bronze or brass forgings. It may also be used advantageously in structural steel and sheet metals when it reduces driving torque and resists shear and tension loads and in impregnated plywoods where it grips with rugged strength. The pilot with its five tapping flutes cuts a machine thread as the screw is turned in—does the job with complete dependability—stays tight and secure.

P-K TYPE "B-F"

P-K TYPE B-F For plastics, P-K recommends the new improved "Pentap", Type B-F (Patented). This exceptionally efficient thread-cutting screw combines the five thread-cutting flutes of the P-K Type F with the coarse-pitch, widely-spaced threads of the P-K Type B screw. Thus it distributes cutting pressure evenly, lets chips drop to the bottom of the hole and prevents cracking of the material. The B-F is designed for making fastenings to comparatively thin sections and bosses in friable and brittle plastics.

SPECIAL FOR NYLON P-K TYPE L

P-K TYPE "L"

For this very popular material, only Parker-Kalon has a completely new tapping screw—especially developed for use in nylon. It is called the P-K Type L (U.S. Patent 2,350,346). The Type L functions as a combination thread-cutting and thread-forming screw in that it cuts a small amount of nylon while allowing the full diameter of the threads to form. The new P-K Type L offers a particular advantage in nylon assemblies which must be disassembled for service because the Type L can be readily removed and replaced without stripping or galling.

USING THREAD-CUTTING SEMS?

SEMS

Specify P-K, and get thread-cutting screws with a higher drive-strip ratio, *plus* the added holding power of a pre-assembled washer!

P-K Sems are readily available with a wide variety of washers pre-assembled to thread-cutting screw types "F" and "B-F". They may be ordered with slotted, Phillips or Hex heads. They can be hopper fed for automatic driving. Inspection rejects due to omitted lock washers are impossible. Fastenings stay tight and firm.

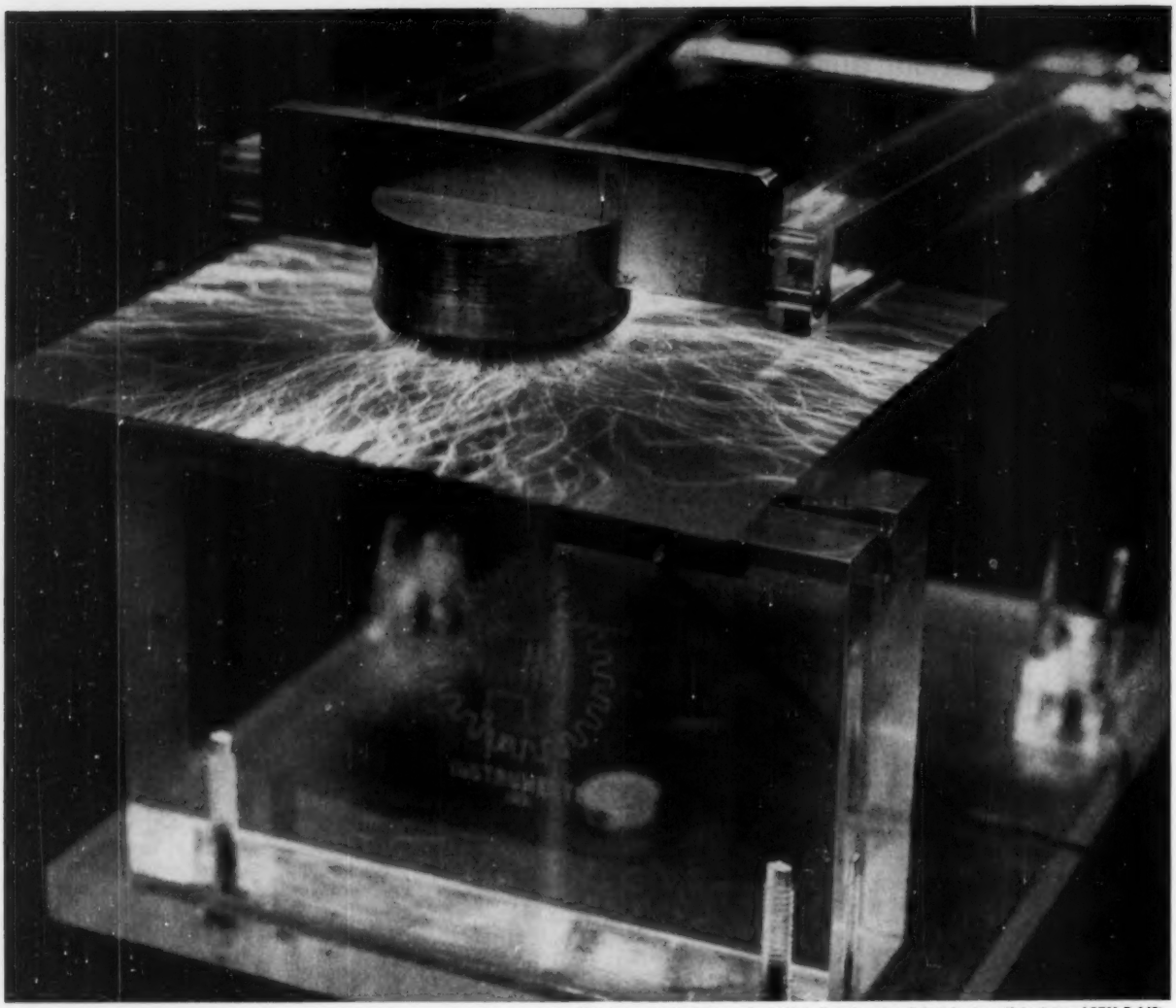
P-K Sems reach your assembly line pre-assembled, ready for instant use. They assure concentric washer seating—washers cannot come off. Double inventory and parts handling is completely eliminated.

P-K Sems are also available with a wide variety of washers pre-assembled to thread-forming and machine screws.

Use the Function Factor formula and prove to yourself that Parker-Kalon thread-cutting screw types F and B-F consistently perform at a higher drive-strip ratio. Their use will increase production efficiency and reduce the "in-place cost" of fasteners in assembly operations. Production run samples may be obtained from your P-K Distributor, or write direct to the Parker-Kalon Sales Engineering Department.

PARKER-KALON *fasteners*

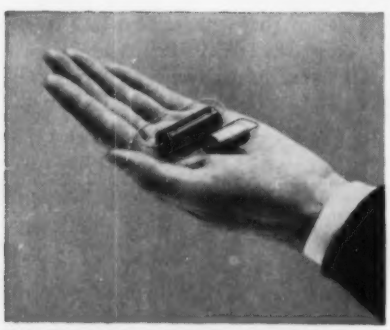
PARKER-KALON, a division of General American Transportation Corporation, Clifton, New Jersey. Offices and warehouses in Chicago and Los Angeles.



This is an actual photograph of "Mylar" undergoing dielectric strength test (per ASTM-D-149).

MYLAR® has a dielectric strength of 4,000 volts per mil

Can the unique combination of properties found in "Mylar" help you solve your design problems?



High dielectric strength helps cut capacitor size. Tough, thin "Mylar" with a dielectric strength of 4,000 volts per mil for 1 mil film (per ASTM-D-149) permits capacitor manufacturers to reduce size of finished unit . . . improve performance and reliability.

"Mylar"* polyester film is a tough, flexible engineering material. In addition to its outstanding dielectric strength, "Mylar" has an average tensile strength of 20,000 psi, withstands temperature extremes (-60° to 150° C.) . . . resists most chemicals and moisture.

On an area basis, tough, thin "Mylar" often *costs less* than heavier, conventional materials. "Mylar" can be laminated, embossed and metalized, punched or coated. The film won't embrittle with age. "Mylar" is available in roll or sheet form in a wide range of gauges.

Find out how the *combination of properties* in "Mylar" can help you solve knotty design problems, improve product performance or cut costs. Write for our booklet containing detailed information on properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Room P-9, Wilmington 98, Del.

*"*Mylar" is Du Pont's registered trademark for its brand of polyester film.*

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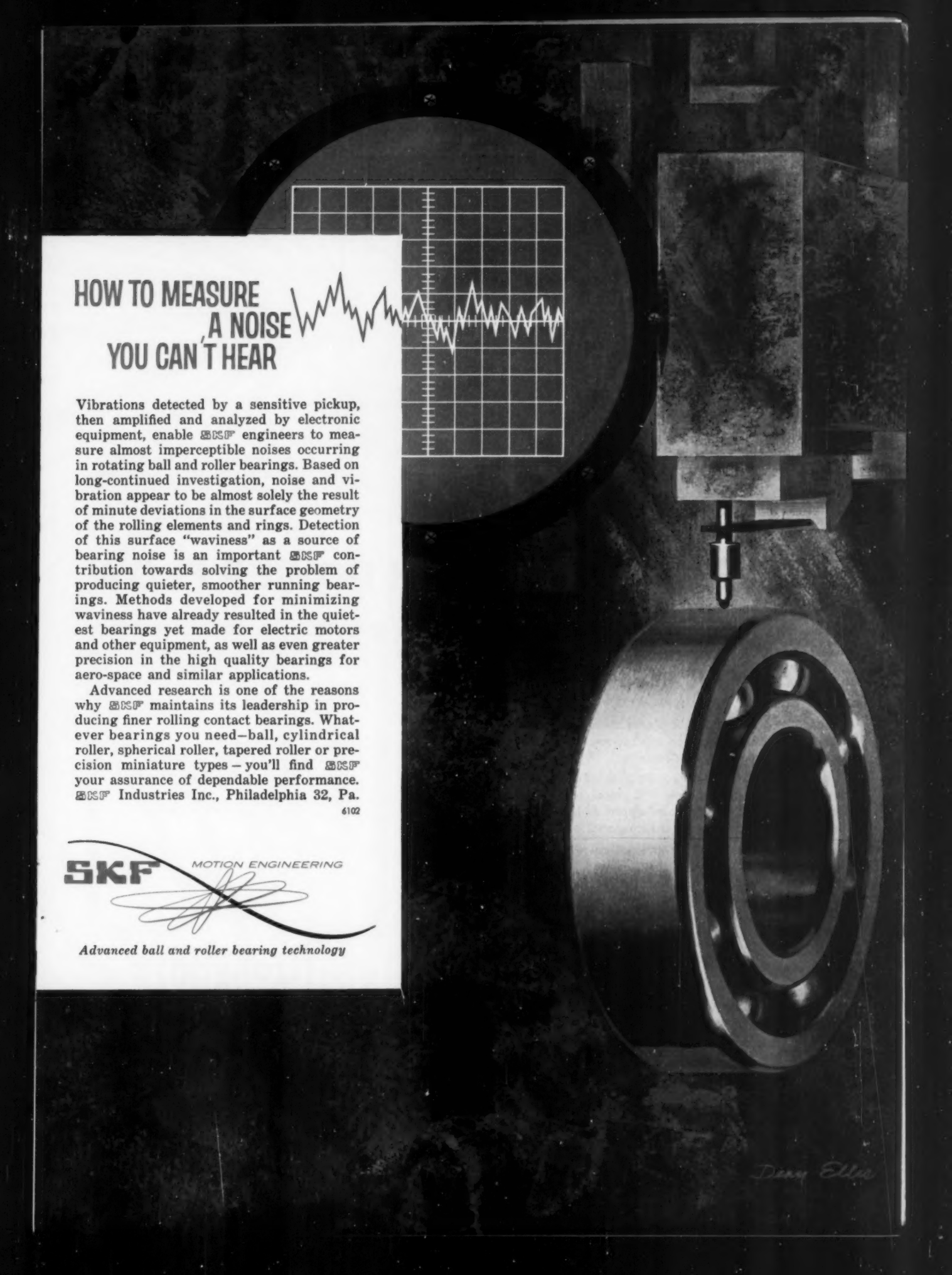
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

DU PONT MYLAR® POLYESTER FILM

See Du Pont's complete line of Industrial Films at the IRE Show, Booth #4329-31



HOW TO MEASURE A NOISE YOU CAN'T HEAR

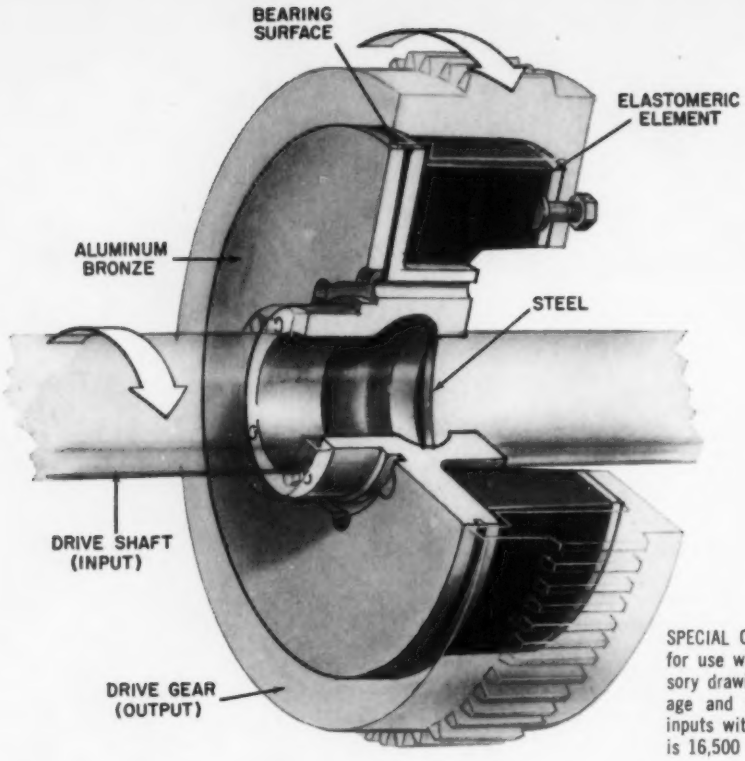
Vibrations detected by a sensitive pickup, then amplified and analyzed by electronic equipment, enable SKF engineers to measure almost imperceptible noises occurring in rotating ball and roller bearings. Based on long-continued investigation, noise and vibration appear to be almost solely the result of minute deviations in the surface geometry of the rolling elements and rings. Detection of this surface "waviness" as a source of bearing noise is an important SKF contribution towards solving the problem of producing quieter, smoother running bearings. Methods developed for minimizing waviness have already resulted in the quietest bearings yet made for electric motors and other equipment, as well as even greater precision in the high quality bearings for aero-space and similar applications.

Advanced research is one of the reasons why SKF maintains its leadership in producing finer rolling contact bearings. Whatever bearings you need—ball, cylindrical roller, spherical roller, tapered roller or precision miniature types – you'll find SKF your assurance of dependable performance. SKF Industries Inc., Philadelphia 32, Pa.

6102

SKF MOTION ENGINEERING

Advanced ball and roller bearing technology



SPECIAL COUPLING was designed by Lord for use with gear in diesel engine accessory drawing. It protects gears from damage and wear by isolating 8° torsional inputs with 98% efficiency. Torque rating is 16,500 in.-lbs. at 850 rpm.

DESIGN FOR SMOOTH POWER FLOW

with custom-engineered

Lord Flexible Couplings

Torsionally resilient couplings offer important operating advantages for many power transmission applications. Here's what Lord can give you in a special flexible coupling:

Custom design. Couplings can be designed to meet any specific requirements. They can incorporate any degree of flexibility in one or more modes. Elastomers can be specially compounded to resist extreme temperature and oil environments.

Smooth power flow. Lord Couplings provide constant speed transmission of power with no backlash. Torsional disturbances are efficiently isolated. Varying degrees of misalignment—angular, parallel, axial—can be accommodated simultaneously.

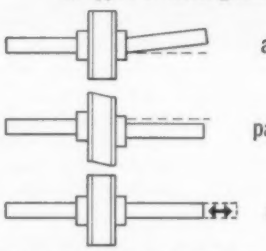
Reliability. Simplified design—no gears, seals, bearings or metal-to-metal contact—assures long service life. Resilience protects driven equipment from damaging inputs and extreme overloads.

Special features. Torque capacities from inch-ounces to foot-tons. Permanently quiet operation. Attenuation of shaft-borne noise. No lubrication or maintenance. Minimum size for given horsepower. Optional fail-safe protection.

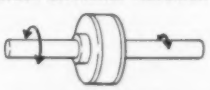
Package assembly. All these features can be incorporated in a special coupling designed by capable, experienced engineers. Your custom couplings will arrive precision produced, fully tested, ready to do your job.

Get more details from your nearest Lord Field Engineering Office or the Home Office, Erie, Pa.

Lord Flexible Couplings accommodate all types of misalignment:



. . . and isolate torsional vibration and shock:



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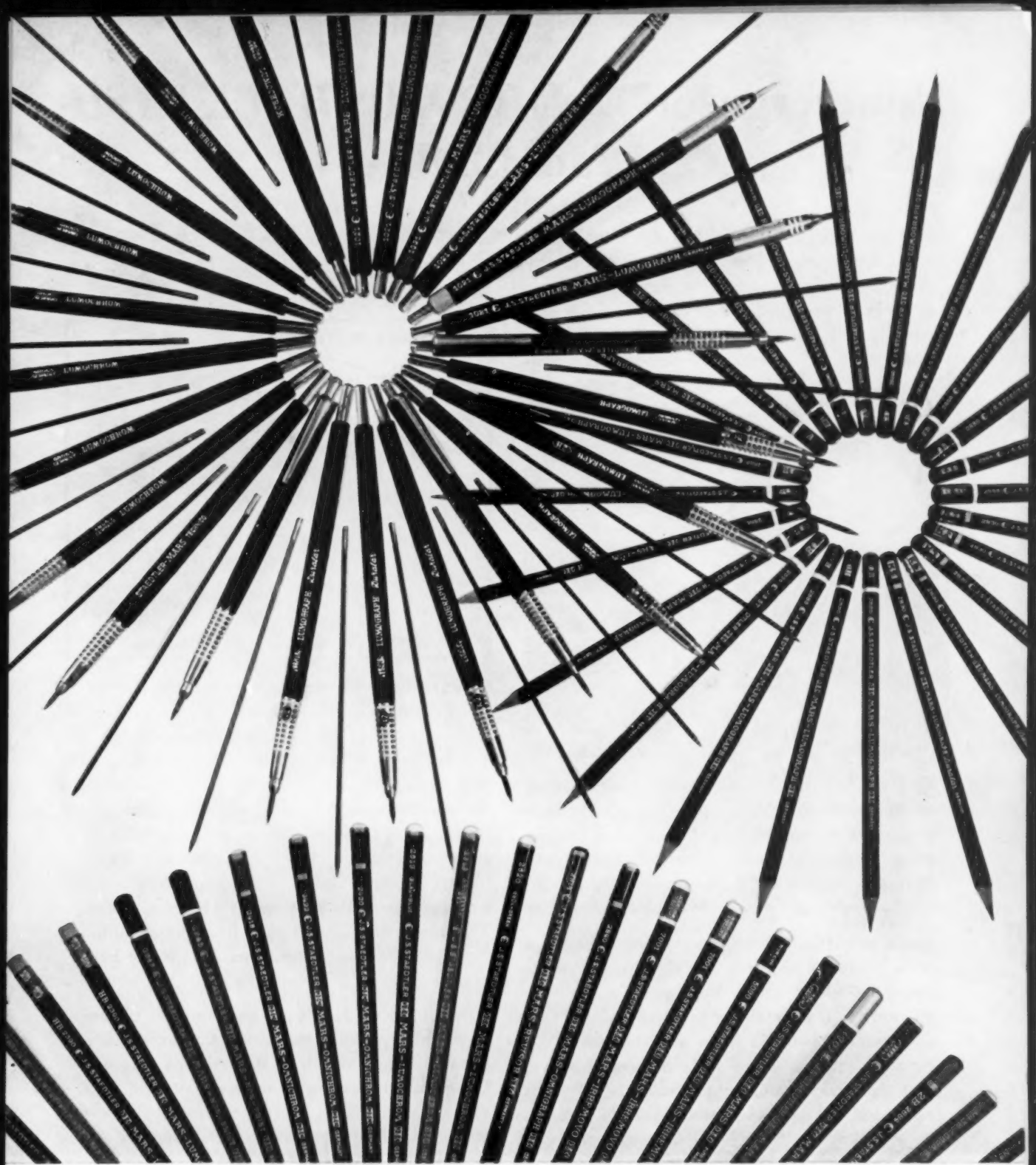

ALL MARS – ALL TOPS

.... all imported from West Germany, made to meet the highest standards of professionals.

the pencil that's as good as it looks

MARS

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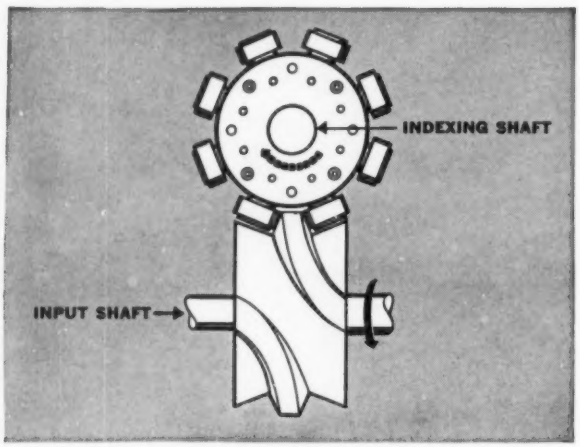
HACKENSACK, NEW JERSEY

Mars products are available at better engineering and drafting material suppliers everywhere.

How Ferguson *ELIMINATES BACKLASH* in Index Tables

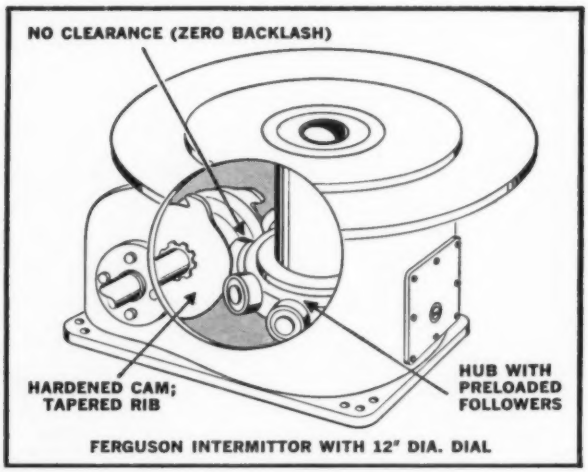
Backlash in indexing results in shock loads that affect the efficiency of a machine and the quality of its product. Most indexing mechanisms have inherent characteristics that cause backlash and poor dynamic conditions and prevent the designer from taking full advantage of modern feeds, tooling and methods that contribute to production economy.



Ferguson Intermittor Index Tables have inherent zero backlash and extreme precision which results in a rotary transfer machine base capable of operating speeds up to 500 indexes a minute. *A Ferguson index table never proves to be a limiting factor in the speed or performance of an automatic assembly machine.*

HERE'S WHY: The continuously rotating cam of a Ferguson indexing mechanism features a *tapered rib* along which two preloaded bearing followers roll, maintaining constant contact with no clearance between them and the rib. When the mechanism is in the rest, or dwell, position, a straight portion of the rib locks the followers with zero backlash and an indexing accuracy of .001". Wear on the hardened tool steel cam is infinitesimal (many have been in use for more than 25 years). Followers are rated for a minimum of 8,000 hours operation. If backlash occurs after this period the life of the drive may be renewed merely by replacing the standard followers.

NOTE HOW PRELOADED FOLLOWERS ENGAGE RIB



FERGUSON INTERMITTOR WITH 12" DIA. DIAL

Compare this with other types of indexing devices. A geneva drive, with its slotted wheel and driver, and a barrel cam with a grooved track which engages one follower at a time, must have clearance in the slot or groove to allow passage of the follower. The slightest amount of clearance causes backlash. As the slot or groove wears, the clearance becomes greater and the backlash condition worsens. At the higher, more profitable operating speeds poor dynamics cause wear on other parts of the machine. The user must choose between frequent downtime for repairs or slower speeds . . . He is the loser in either case.

FREE DESIGN DATA — Load ratings, dimensions and application and installation information about standard and stock Intermittors, Ferguson Drives and in-line machines are contained in a single 36 page catalog. Every designer should have one in his library . . . Write Ferguson—Ask for Catalog No. 160.

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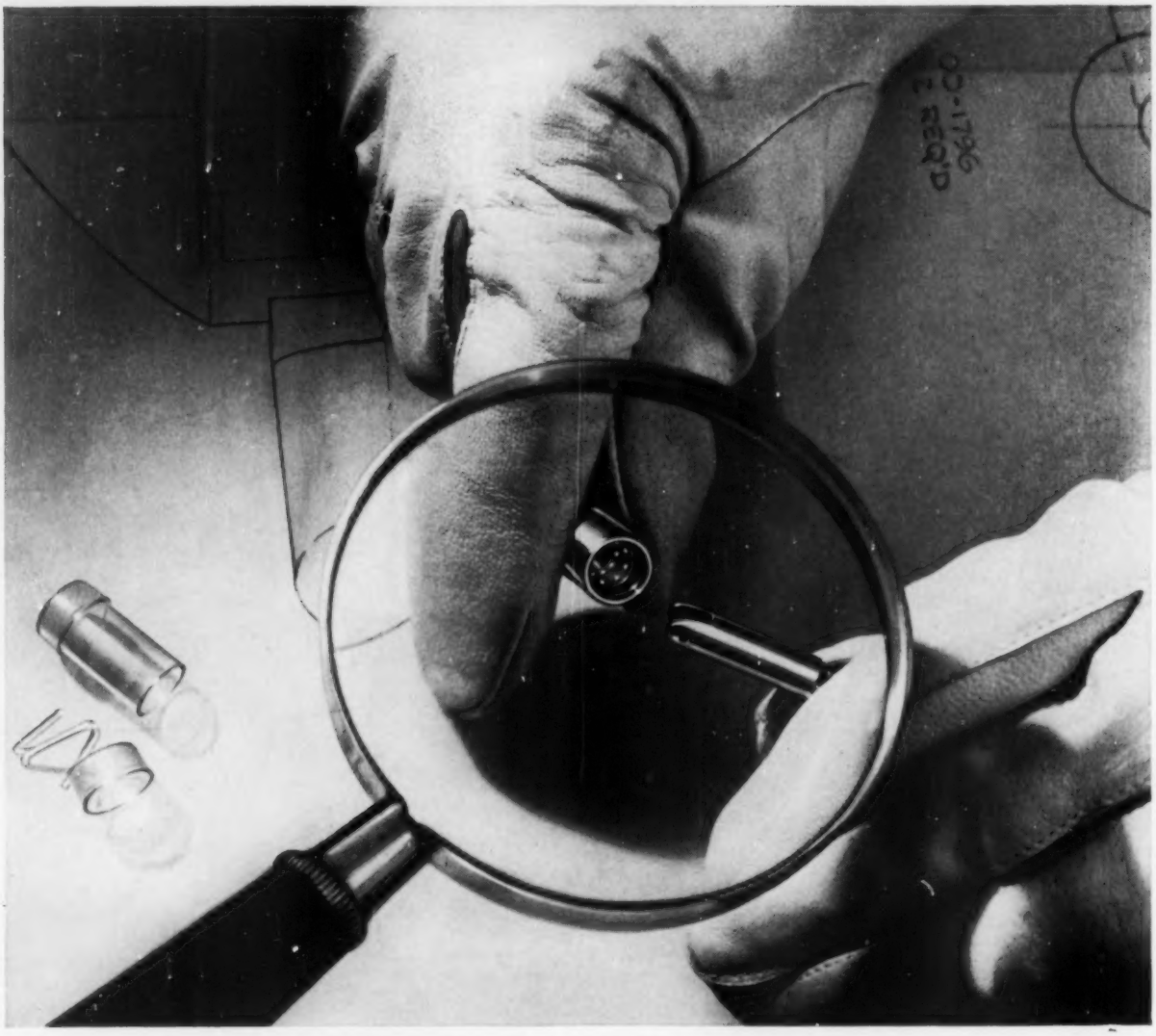
NEW DEPARTURES IN MINIATURE



HOW TO GIVE ON-THE-NOSE GUIDANCE TO MODERN "FISH"

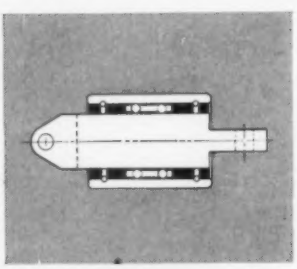
UNIQUE N/D LINEAR MOTION BEARING FREES GYRO CAGING ACTION

The bearing illustrated is an N/D linear motion precision instrument ball bearing. It was specially designed and built to help solve a critical problem in the guidance system of a high speed anti-submarine torpedo.

PROBLEM: Loss of accuracy in torpedo's guidance system due to hang-up of caging arm in gyro assembly.

SOLUTION: N/D Sales Engineer, in cooperation with manufacturer, found that *wear* of bushing on caging arm caused hang-up, delaying guidance activation. N/D Engineers set to work to design and build an instrument bearing that operates virtually friction-free. The result: Preservation of the guidance system's pin-point accuracy and reliability.

Should you require ball bearing design information, invite the local N/D Sales Engineer to participate in your early design discussions. He represents one of the industry's largest engineering staffs devoted exclusively to the design and development of miniature and instrument ball bearings. Or, write for new Miniature and Instrument Ball Bearing Catalog, Department L.S., New Departure, Division of General Motors Corporation, Bristol, Connecticut.



This special N/D linear motion instrument ball bearing increased guidance reliability of ASTOR torpedo weapon system developed by Westinghouse.

NEW DEPARTURE
MINIATURE AND INSTRUMENT BALL BEARINGS

PRODUCT ENGINEERING HORIZONS

MARCH 13, 1961

INDUSTRIAL BABY-SITTER?

Hippocrates, the author of the Hippocratic oath and the father of medicine, first propounded the idea, two millenia ago, that the seat of thought is in the brain rather than the heart. But neither he nor any of his descendants until recently ever imagined that the seat of much of our perception is neither in the brain nor the heart but in the seat itself. Parents have known it instinctively, and have long used the seat as a way of impressing corrective ideas.

All of this has become of engineering importance during the past two decades, during which mechanization has progressed so rapidly that many of us have become merely baby-sitters for machines. A whole new field of endeavor has, in fact, been opened in human-engineering comfortable seats, benches and leaning rails for operators (*PE*—Aug 22 '60, *p* 40). The leading authority in this field, the orthopedist Dr Janet Travell, has just been called to Washington to serve as personal physician to the President, thus postponing, if not cancelling, some months of our negotiations with her for an article on seating. (She designed, for example, the seat for the new John Deere tractor (*PE*—Dec 5 '60).

In the early days of aerial barnstorming, flyers were said to "fly by the seat of their pants." Then flying, too, became mechanized. But an Air Force doctor, commendably curious about the old expression, gave himself a massive injection of novacaine in the gluteus maximus muscles, then had a friend take him up in a fast trainer. When he took over the controls, he almost crashed the plane; he found that his sense of balance was seriously affected, and that in fact a dead seat is much worse than a dead stick.

Recently, engineers at North American had a similar unsettling experience. A pilot testing a new plane reported a dangerous vibration in the engine. Instruments placed by the engineers showed no problem, so the report was considered one of the familiar phenomena in which the human mind plays tricks on its owner. After all, it is well known that under some conditions a pilot doesn't even know if he's flying right side up.

But the pilot was insistent. The engineers were properly skeptical, but they hit upon a simple test. They seated the pilot on a vibration table and told him to report when the vibration became, in his opinion, dangerous. Then they tried various vibratory cycles and amplitudes. *In each case, he reported dangerous vibration within a percent or two of the danger zone shown on their instruments.*

This suggested that they might be able to identify the particular vibration that the pilot felt was causing the trouble. So again they tried various combinations, until the pilot said, "That's the one." With this lead, they traced the vibration to the exhaust line—which was transmitting its own vibration to the engine. It was dangerous and the pilot's contention was proved.

All of which brings us to the point that a computer or numerical control or automation may take over some functions of the brain, and a heart pump may replace the heart, but never assume they've all been taken over.

Lamb Electric's "Clean Room" insures fractional horsepower motor perfection

For assembly of small precision gear motors, Lamb® Electric has installed an air-conditioned, dust-free "Clean Room". This innovation, primarily for the assembly of these custom-built motors, is essential for eliminating even particles of dust.

The "Clean Room" is typical of progressive Lamb thinking that insures perfection in fractional horsepower motor design and manufacture.

Do you have a special motor problem? . . . Here's what you can expect from Lamb! *Into the design* of a Lamb motor goes years of experience in powering components for aircraft, domestic and industrial products. *Out of the design* comes a personalized motor that's dependable, smooth and efficient.

Cost-wise you're way ahead, because Lamb Motors are mass-produced at the most favorable cost.

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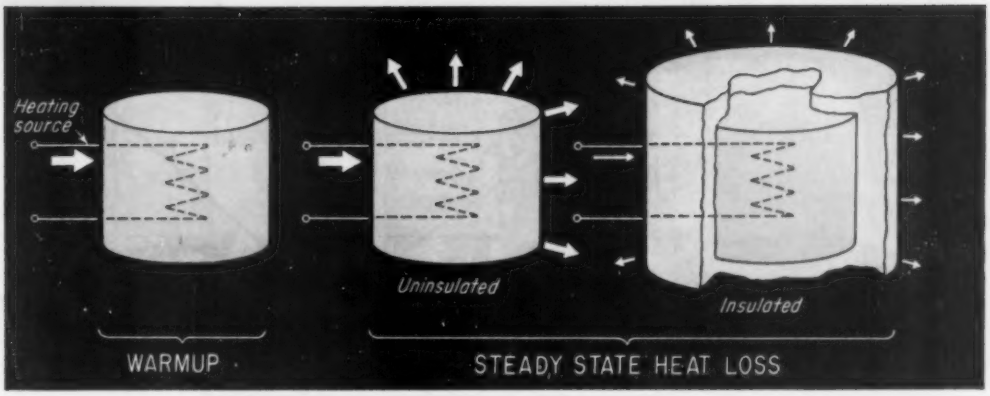


shortcut charts estimate heat for . . . .

KEEPING THE COMPONENT WARM

For most applications the heat you need to warm up a component and keep it warm can be quickly estimated with these charts based on experience.

RALPH CRUMP, *chief engineer*
Electrofilm Inc, North Hollywood, Calif

Before specifying a heater to keep a part or component warm, you have to know what the heat loss from the part will be. Rigorous thermal calculations will work, but mistakes are easy to make unless you are expert with math.

A shortcut estimate, using the accompanying charts will often do the job, and lessen the risk of careless mistakes. Along with speed, the method gives fairly good accuracy when the object is not too large (its surface area should be less than 3 sq ft), is smoothly contoured, and is operating in relatively still air. Examples are instrument cases, insulated valves, and small ovens. All heat is assumed to be dissipated from the surface by combined natural convection and radiation.

For larger areas, accuracy is slightly less; figure that heat loss by combined convection and radiation from downward-facing surfaces will be 80% of the over-all average values assumed in the heat-loss charts given on next page for uninsulated surfaces.

If heat loss by conduction through uninsulated mounting brackets to a large metal heat sink is expected, specify 10 to 12% extra heater capacity (for bracket contact areas up to 15% of total surface area).

The method is not usually recommended where there is forced convection because air velocity radically changes the surface heat-transfer coefficient. However, for insulated parts the greatest thermal resistance is in the insulation, and changes in the surface coefficient have relatively little effect on over-all transfer.

Expected accuracy

In most warming applications, where the limiting conditions are met, experience has proven that the charts give as good or better answers than those calculated with handbook values for conduction, convection and radiation. This is because the charts are based on over-all heat balances under actual operating conditions using typical small components.

Correlation is often better than ±10% of actual heat flow. To get closer values, you can make detailed calculations or run a heat-balance test after the component design is better established.

WHAT THE CHARTS ARE

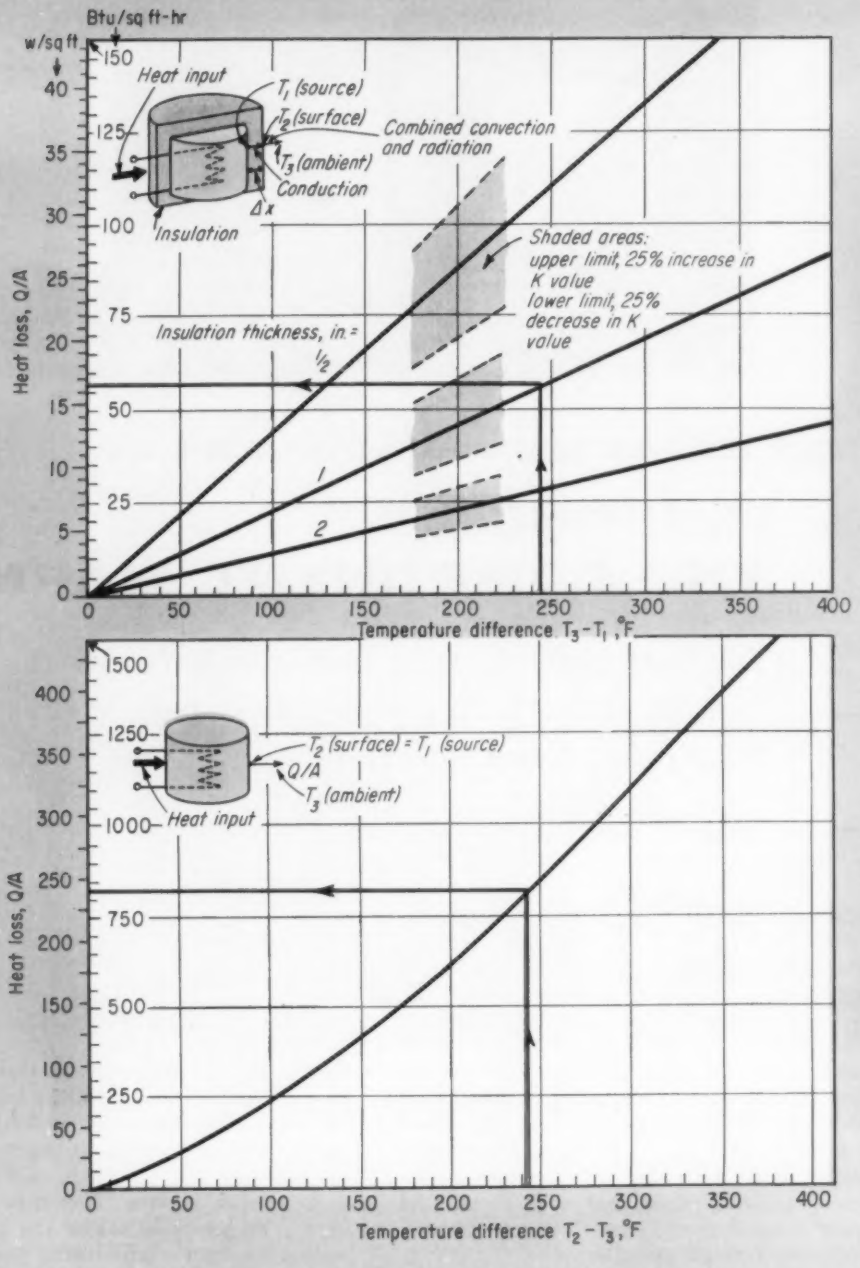
The charts on the next page are simplified plots of actual heat-balance data taken over a period of 10 years on all types of heated bodies in still air. Convection and radiation are not kept separate, but are combined—just as they are combined in actual operation.

The chart for an insulated heat source combines conduction, convection and radiation. Its companion, for an uninsulated heat source, gives heat dissipation by convection and radiation, assuming that surface temperature is

text continued, page 63

REPRINTED—Circle 593, inside back cover

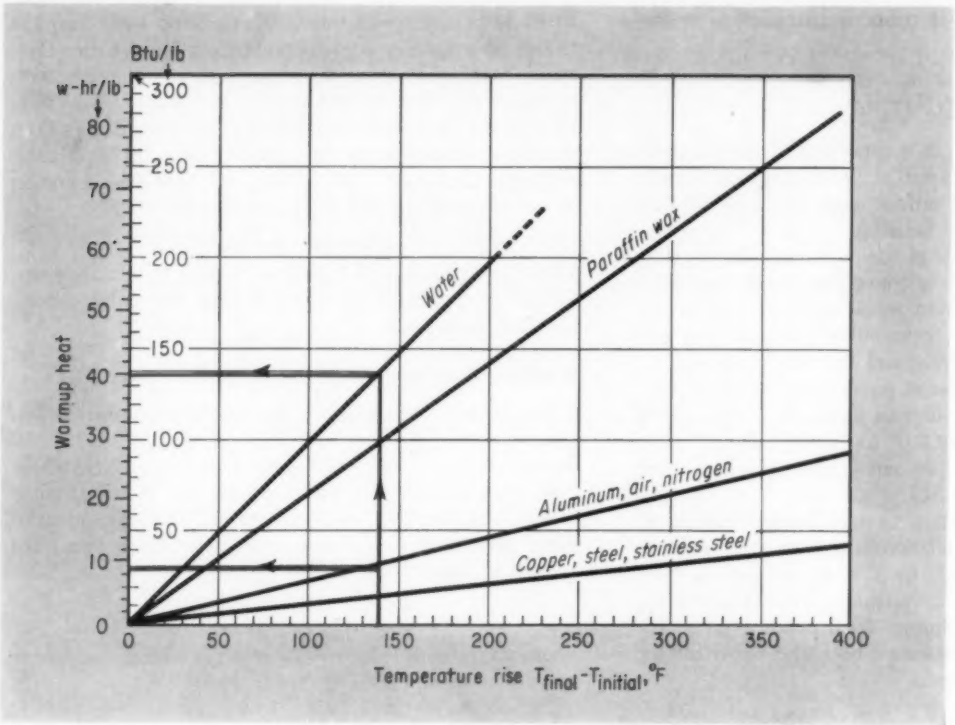
HEAT LOSS, STEADY-STATE



TO MAINTAIN COMPONENT TEMPERATURE at a fixed value in a given ambient, just supply the heat indicated by the graphs. Each curve is based on actual tests of hundreds of small components such as valve bodies and instrument cases. **Upper chart**—for insulated components—has conduction, convection and radiation lumped together. Conductivity of insulation (protective cover included) is assumed to be 0.02 btu/sq ft-hr °F/ft. **Lower chart**—for uninsulated components—has convection and radiation lumped together, but assumes infinite conductivity. The surface convection-radiation values in lower chart are also contained in lumped values for upper chart. Article gives limitations for both charts.

Example using upper chart: A component with 2.5 sq ft of surface area has 1-in.-thick insulation. How much heat will it take to maintain this body at 180 F if ambient is —65 F? Method: enter graph at 180— —65 = 245 F temperature difference. Move up to 1-in. insulation line, then left to Q/A = 57 btu sq ft-hr or 16.7 w/sq ft. Answer: 2.5 × Q/A = 142.5 btu/hr, or 41.7 w.

Example using lower chart: A component with 2.5 sq ft of surface area has no insulation. How much heat will it take to maintain this body at 180 F if ambient is —65 F? Method: Temperature difference is 245 F (abscissa); therefore heat loss is 825 btu/sq ft-hr or 242 w/ sq ft. Answer: 2.5 × Q/A = 2063 btu/hr or 605 w.



WARMUP HEAT for any body is its weight, times specific heat, times temperature change. If there will be a change in state, don't forget to add latent heat.

Example, using chart: How many watts to increase temperature of 4 lb of water in a 6-lb aluminum pot from 40-F initial to 180-F final temperature?

Method: Rise is 140 F. Read 30 btu/lb or 9.5 w-hr/lb for aluminum, and 138 btu/lb or 41 w-hr/lb for water. Answer: total lb × (warmup heat/lb) = 6 × 9.5 + 4 × 41 = 221 w-hr. If warmup time is to be ¼ hr, then power level during warmup is 4 × 221 = 884 w.

the same as body (source) temperature. The third chart, for warmup heat, assumes negligible heat loss during the short warmup time and plots the btu's needed to raise 1 lb of several common materials through various temperature changes. All charts are good for temperature differentials of from zero to 400 F, in the range from −200 F up to limit of charts.

Equations for charts

The first two charts can be represented mathematically with a simplified equation that treats conduction, convection and radiation as additive quantities. In final form, the over-all relationship is:

$$Q/A = (T_1 - T_2) / (R_1 + R_2)$$

where Q/A is over-all heat transfer from source to surroundings, in btu/hr per sq ft; T_1 is source (body) temperature, °F; T_2 is ambient temperature, °F; R_1 is thermal resistance of the insulation; and R_2 is thermal resistance of the convection and radiation portions of the system.

Thermal resistance R_1 is the reciprocal of thermal conduction $K/\Delta x$, where K is conductivity in btu/sq ft-hr per °F/ft, and Δx is thickness of insulation, ft, in the direction of heat flow. Thermal resistance R_2 is the reciprocal of total surface heat-transfer coefficient h_t, which has units of btu/sq ft-hr per °F (simplified).

Both R_1 and R_2 are "defined" properties, and serve only to simplify the math. More details of the actual mechanism of heat transfer, including the derivation of R_1 and R_2 are given in the section on theory that follows.

The third chart solves the standard equation $H = C_p (T_f - T_i)$, where H is heat capacity of the body being warmed, btu/lb; C_p is specific heat, btu/°F-lb; T_f is final temperature, °F; and T_i is initial temperature, °F.

Typical Blanket Insulation

	Density, lb/cu ft	Max temp, °F	Conductivity, K btu/sq ft-hr per:	
			°F/ft	°F/in.
Fiberglass:				
Unbonded	3.0	1000	0.02	0.24
Resin-bonded	1.0 0.5	450		
Styrene, foamed	3.0	175	0.021	0.25
Polyurethane, foamed	2.0	200	0.013	0.15

HEAT-TRANSFER THEORY

The over-all relationship $Q/A = (T_1 - T_2)/(R_1 + R_2)$ is developed from separate expressions for conduction,

convection and radiation heat transfer. Each expression is simplified here so that it contains temperature to the first power only:

Conduction	$Q_1/A = K\,(T_1 - T_2)/\Delta x$
Convection	$Q_2/A = h_c(T_2 - T_3)$
Radiation	$Q_3/A = h_r\,(T_2 - T_3)$

Q is heat flow, btu/hr. A is total area of heat-dissipating surface, sq ft. Q_1/A must $= Q_2/A + Q_3/A$ because all heat conducted to the surface must also leave it, part by convection, the rest by radiation.

K is thermal conductivity of the insulation, btu/sq ft-hr per °F/ft of thickness; h_c is convection coefficient, btu/sq ft-hr per °F; h_r is radiation coefficient, btu/sq ft-hr per °F; T_1, T_2, T_3 are source (component), surface and ambient temperature, respectively; and Δx is thickness, ft.

Although each expression is given in linear form, only the first—for conduction—is truly linear. Conductivity K stays fairly constant at about 0.02 for most insulating materials. Even special materials rarely have K-values more than 0.025 or less than 0.013.

The convection expression is not linear because h_c depends on complicated relationships among air density, viscosity, and specific heat; each is dependent on temperature—which is itself a variable. The radiation expression is extremely nonlinear: h_r depends on the 4th power of absolute temperature of both the warm surface and the cooler surroundings.

Fortunately, when radiation and convection are combined in actual applications, the resulting total heat-loss to the surroundings is predictable, even though the combined coefficient, $h_t = h_c + h_r$, varies nonlinearly with temperature. Within the range of $(T_2 - T_3)$ from 10 to 400 F, h_t varies from 1.5 to 5. But by reading Q/A directly from the curve, the proper value of h_t is automatically included. The combined heat-flow equation upon which the second chart is based is:

$$Q_t = Q_2 + Q_3 = h_t A(T_2 - T_3)$$

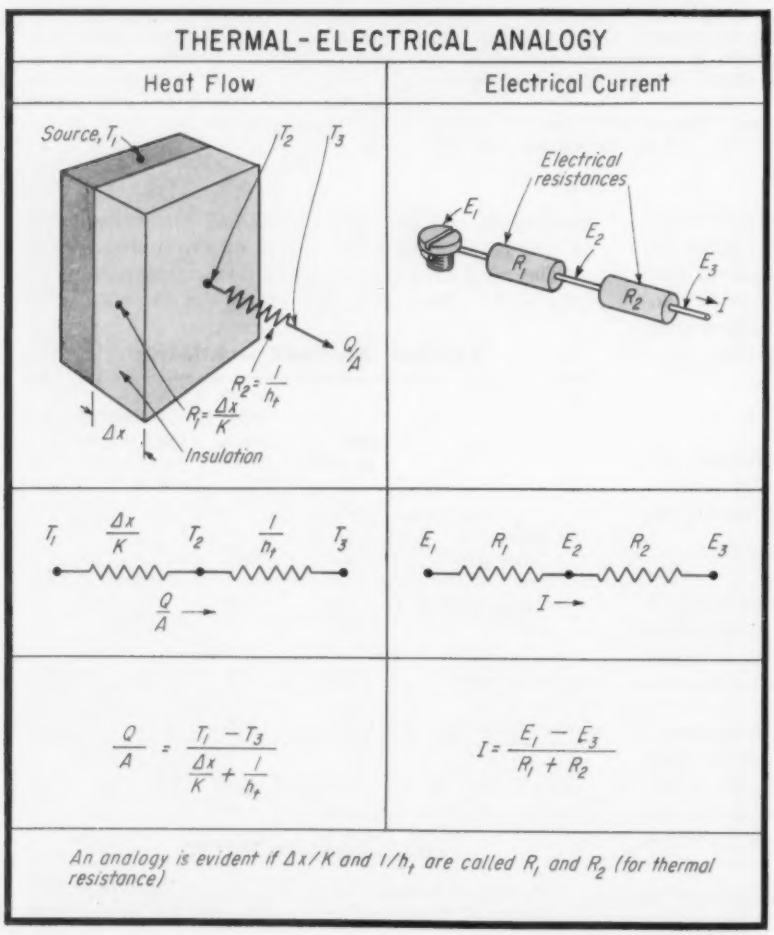
where Q_t is total heat flow from surface to surroundings. Q_t will always equal Q_1 when all heat loss is by convection and radiation.

Electrical analogy

The general relationship for conduction, convection, and radiation, $Q/A = (T_1 - T_3)/(R_1 + R_2)$ is a thermal expression of the familiar Ohm's Law, $I = E/R$, where I is current, E is potential difference, and R is resistance to flow. But first you must put the conduction and combined convection-radiation expressions in these forms analogous to Ohm's Law:

$$Q_1/A = (T_1 - T_2) \,/\, (\Delta x/K)$$
$$Q_t/A = (T_2 - T_3) \,/\, (1/h_t)$$

where $\Delta x/K$ and $1/h_t$ are, in effect, thermal resistances and can be manipulated as shown below, left.



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EDITOR'S NOTE: Heating the product has also been the topic in these recent articles:

Infrared for Heating a Product, Feb 1 '60, p 39—Compares the many external methods of heating, including radiation, convection, induction, conduction and dielectric heating, with handy charts for estimating radiant heating.

Surface-type Heaters (by Mr Crump), Jan 30 '61, p 42—Describes all types of area-source heaters, shows how to choose one over another.

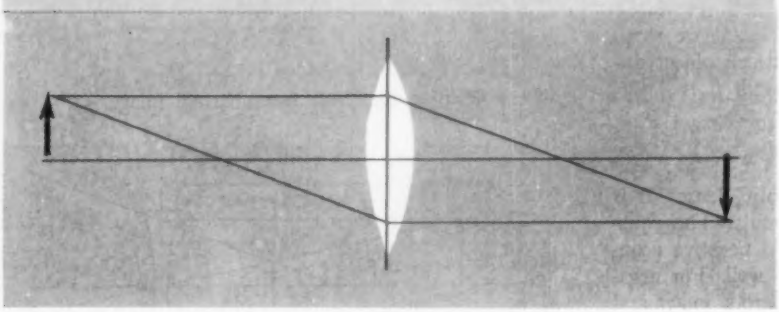
These articles on cooling have also appeared in our pages:

When Air Is the Coolant, Feb 16 '59, p 54—Shows how to estimate whether an assembly will run too hot, and whether the self-cooling methods of radiation or convection can handle the trouble. Has detailed but easy-to-use charts of forced and natural convection.

Radiant Cooling or Shielding, Nov. 14 '60, p 55—Demonstrates how radiation can dissipate large amounts of heat when surface temperature is high. Comprehensive emissivity tables included, along with equations for using them.

—Franklin D Yeaple

Though design of elaborate optical systems is beyond the range of most engineers, simple problems can be solved with just a few rules and inexpensive, off-the-shelf components. Here, with a review of the fundamentals, is a rundown on the typical components and how to use them.



how to design . . .

SIMPLE OPTICAL SYSTEMS

DONALD H CRONQUIST
Santa Clara, Calif

Optical elements instead of mechanical elements? That's a design alternative you may easily overlook. The optical elements, like their electronic and hydraulic counterparts, have a valid place in today's designs. Why, for example, amplify motion mechanically when it can be magnified by a simple lens system? Why move a part at high speed when moving its image will serve as well? Why sense position electronically when an optical system will do the same job cheaper, more accurately and more reliably? Then there's the matter of inertia. Beams of light have no weight; they can be stopped and started instantaneously. They can sense speed and bearing of a moving object without touching it or slowing it down.

Too often, designers ignore the benefits of an optical system because they have been persuaded it is a job for experts. Design of a high-resolution telescope or a special wide-angle lens certainly is not for amateurs. But lenses and prisms can be bought ready-made. You don't have to understand their mathematics any more than you have to be a gear expert to pick gears out of a

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catalog. A few simple rules and a knowledge of what can be done with the available elements is all you need.

LENSES—THE CRITICAL COMPONENTS

The most important elements in an optical system are the lenses. Without a lens, there is no way to form an image and no way of modifying that image. This ability to modify—bend, invert, make larger or smaller, lighter or darker—is the chief advantage of the optical system. What kind of image? How bright? Where should it be placed? How big the lens? How much magnification? What focal length? These are the questions you must answer when choosing a lens.

Image location

The basic lens equation is a simple one. As we recall from elementary physics, the relation between object distance L, image distance L', and focal length F is

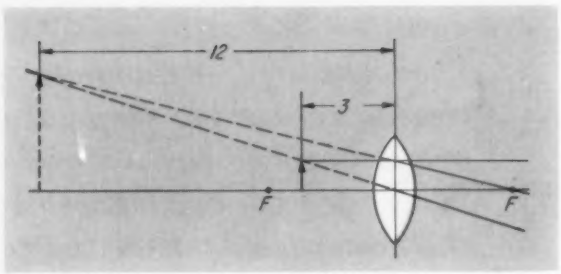
$$\frac{1}{F} = \frac{1}{L} + \frac{1}{L'}$$

Though this applies only to idealized "thin" lenses, it is adequate for all but the most precise layouts. The equation applies both to positive (convex) and negative (concave) lenses—and to parabolic mirrors as well. For negative lenses, focal length is negative; for mirrors, image and object distances are measured in the same direction.

Two kinds of images can be formed: real and virtual. Real images actually exist in space and are the kind you see when a projector throws a picture on a screen. Virtual images are formed when the lens teams up with the lens of your eye, the most familiar example being the image you see when looking through a magnifying glass. (A third kind of image, the aerial image, is really only a special case of a real image. To see an aerial image, look through a magnifying glass held at arm's length and see an inverted image; it is that part of the real image framed by the lens.)

Real images can be detected by a photocell, magnified by additional lenses, or thrown on a screen where they can be viewed by many people at once. Virtual images can be seen only with the eye, and ordinarily, by only one person at a time. But the virtual image is erect (same orientation as object) and because light paths are short, the system can be quite compact. And, like the aerial image, virtual images need no light-scattering screen to be seen. They therefore appear much brighter than equivalent reflected real images.

If we reexamine the basic lens equation we find that it not only locates the image, but tells the kind of image that will be formed. Distances to the right of the lens are considered positive; distances to the left, negative. When L' (in this article, the prime notation denotes symbols that refer to the image) is of opposite algebraic sign to L, the image is real; when L' has the same sign, the image is virtual. For negative lenses, the image is always virtual except when the image of a previous lens falls on the image side of the negative lens and acts as a "virtual" object for that lens. Three brief examples will illustrate the use of the equation.

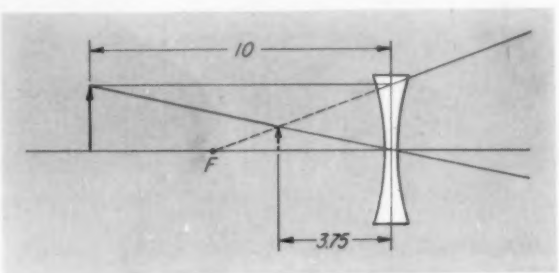


1. A positive lens with a focal length of 4 in. and an object 3 in. from lens will form an image as above. Image distance is

$$\frac{1}{L'} = \frac{1}{F} - \frac{1}{L} = \frac{1}{4} - \frac{1}{3}$$

$$L' = -12$$

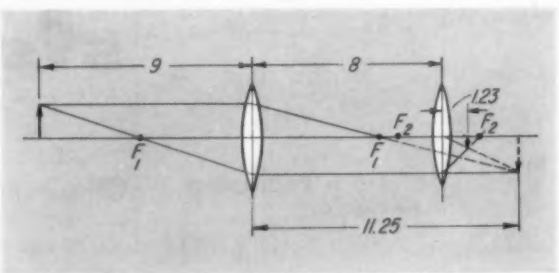
where negative sign indicates a virtual image.



2. A negative lens ($F = -6$) is placed 10 in. from an object. Virtual image is located at

$$\frac{1}{L'} = -\frac{1}{6} - \frac{1}{10} = -\frac{8}{30}$$

$$L' = -3.75$$

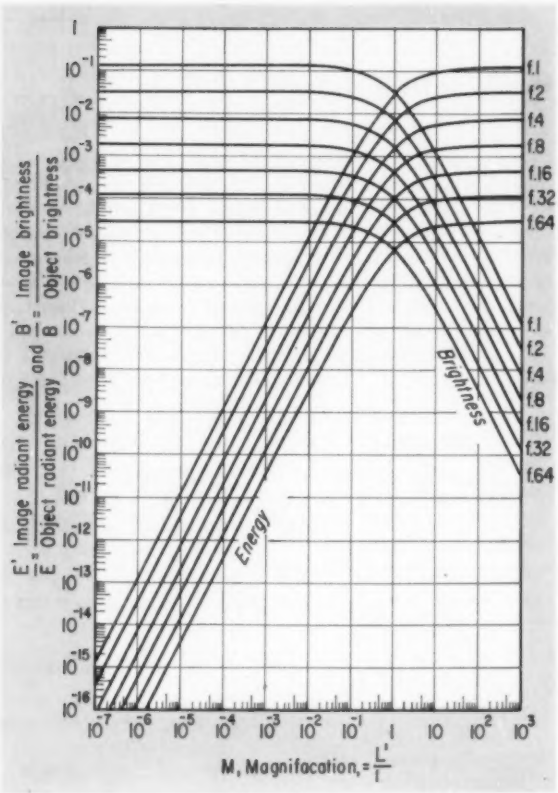


3. Two positive lenses ($F_1 = 5$, $F_2 = 2$) are placed 8 in. apart and an object placed 9 in. in front of the first lens. The real image of this first lens falls at

$$\frac{1}{L'_1} = \frac{1}{5} - \frac{1}{9} = \frac{4}{45} \qquad L'_1 = 11.25$$

forming a virtual object for the second lens. Image of the second lens is located at

$$\frac{1}{L'_2} = \frac{1}{2} + \frac{1}{3.25} \qquad L'_2 = \frac{26}{21} = 1.23$$



Magnification

Magnification M of a lens system is defined as

$$M = \frac{H'}{H} = \frac{L'}{L}$$

where H and H' are the heights of object and image respectively. When image is upside down with respect to object, magnification is shown as negative. Applying this equation to some simple optical instruments we find, for example, that for a magnifier, the equation reduces to

$$M = \frac{10}{F} + 1$$

in which it is assumed that the virtual image is formed 10 in. from the eye (minimum distance for average eyes). If the image at infinity (the usual case when the lens is adjusted for most comfortable viewing) the equation is $M = 10/F$.

For a telescope containing an objective lens with focal length F_o and an eyepiece with focal length F_e, the magnification is:

$$M = -\frac{F_o}{F_e}$$

in which it is assumed that focal points of eyepiece and objective lens coincide.

Image illumination

Besides focal length, the other important lens parameter is its diameter—it influences image illumination. Such illumination is not only important in optical systems where the image falls on a photocell or other control element, but it should also be checked when comparing effectiveness of alternative optical instruments in which the eye is the sensitive element.

Illumination or brightness, B, is commonly expressed in terms of the radiant energy E per unit area. Thus,

$$B = \frac{E}{A}$$

Image brightness depends, of course, on brightness of source, distance between source and lens, focal length and, as mentioned before, lens diameter. If we assume the source radiates from only one side of a plane surface, the solid angle of the source is 2π. But the lens intercepts only a portion of this energy; that portion is $\pi d^2/4L^2$, where d is diameter of the lens and L is the distance between lens and source. The ratio between radiant energy of image and radiant energy of source (assuming no losses in transmission or reflection) is:

$$\frac{E'}{E} = \frac{\pi d^2}{(4L^2)(2\pi)} = \frac{d^2}{8L^2}$$

When laying out a lens system, it is often more convenient to express this ratio in terms of lens magnification and lens f-number (defined as $f = F/d$); therefore the equations are rewritten:

$$\frac{E'}{E} = \frac{M^2}{8f^2(M+1)^2}$$

and

$$\frac{B'}{B} = \frac{1}{8f^2(M+1)^2}$$

where M is absolute value of magnification. These relationships are plotted on the graph at left above.

This graph is useful when designing systems in which the light from an object passes through a lens and falls on a photocell. From the graph you can determine magnification and f-number needed to give maximum photocell output. With these lens parameters you can then determine object and image distances as dictated by the allowable dimensions of the system.

Ideally the image should be the same size as the photocell. Because this is not always possible, the curves allow you to find conditions of max brightness when image is larger than photocell, or max radiant energy when image is smaller than photocell. Notice there is little gain in brightness with magnifications less than 1/20 and little gain in radiant energy with magnifications greater than 20.

If the layout of lens systems depended only on focal length, f-number and magnification, optical design would be simple indeed. But there are other considerations. Actual lenses usually don't behave like the ideal lenses described by the lens formula—and even the best lenses

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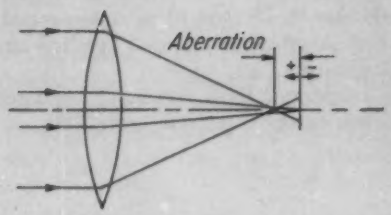
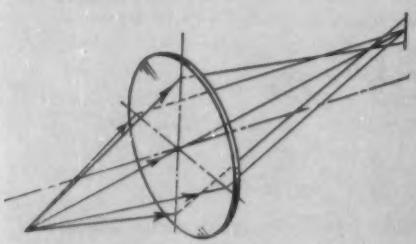
Special lenses minimize these optical defects



Spharical aberration

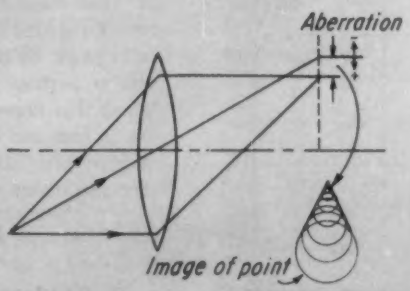
Light through the outer edge of the lens focuses nearer the lens than light through the center. This causes the image to appear blurred over the entire field. The amount of aberration is indicated by the distance between the two focal points. All single-element lenses have some spherical aberration. Partly corrected multi-element lenses can be purchased. Or, because the amount of aberration varies as the square of lens diameter, the effect can be minimized by reducing the aperture.



Astigmatism

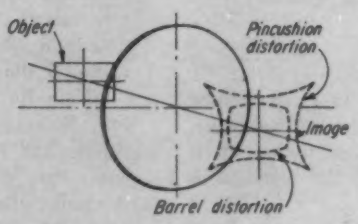
Perpendicular fan-rays from an off-axis source focus at a different point than horizontal fan-rays. If the object were a cross with one arm horizontal and the other perpendicular, the perpendicular arm would be in focus at the near point, the horizontal arm at the far point. Position of best focus is the disk of light between, known as the "circle of least confusion." Astigmatism is independent of lens aperture and varies with square of image height. Images on the axis show no astigmatism except for lenses containing cylindrical or toroidal surfaces.

Astigmatism can be corrected (approximately) with special lens shapes and by reducing the lens aperture, thus eliminating the offending marginal rays. Curiously, many lenses are ground with an overcorrection for astigmatism (negative astigmatism). This is to offset the effect of Petzval curvature. A Petzval surface is the paraboloid formed by the locus of focus points when all astigmatism is removed. It is independent of lens aperture. With negative astigmatism, all points of the image can be brought into a reasonably good focus on a plane surface.



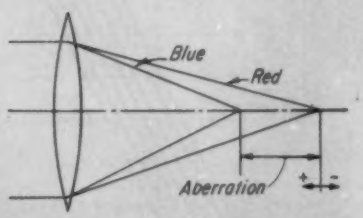
Coma

Light from an off-axis source passes through the center of the lens and focuses farther away from the optical axis than light from the same point passing through the extremities of the lens. The effect gives poor definition of images off the optical axis. The image of an off-axis point of light appears triangular because light passing through successively larger zones of the lens shows as circles successively closer to the lens centerline. As with spherical aberration, coma can be minimized by reducing the lens aperture (where practical) which causes all rays to pass through the lens close to its center.



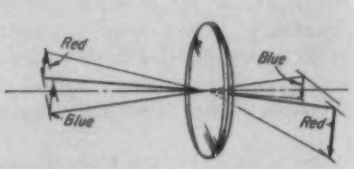
Distortion

Magnification on the optical axis is greater (or less) than magnification off the axis. Distortion causes parallel lines to bow and images to lose their proportion. When axial magnification is greater than off-axis magnification, the lens has positive or barrel distortion; when axial magnification is less, it has negative or pincushion distortion. Distortion does not depend on lens aperture and can be corrected only with specially ground lenses. In general, distortion is not too troublesome except for photographic lenses and systems where precise image measurements are important.



Chromatic aberration—longitudinal

Short wavelengths of light focus closer to the lens than long wavelengths—images appear to be surrounded by a colored halo. Longitudinal chromatic aberration is one of the most objectionable lens defects for systems in which the image is observed by the eye. It can be corrected only by a multi-element lens. It is independent of lens aperture and off-axis image distance. Generally it is corrected only for two wavelengths near each end of the visual spectrum—the wavelengths between remaining slightly out of focus.



Chromatic aberration—lateral

Different wavelengths of light are not equally magnified. The effect is to give "color" to images—an effect which increases with distance from optical axis. It is measured in terms of different image sizes. "Lateral color," as it is called, is a function of off-axis image distance but is not affected by aperture size. Microscope and telescope eyepieces are generally corrected for lateral color by designing an appropriate multi-element lens.

introduce a certain amount of aberration. Though these effects may be small, they cannot be ignored except in the crudest of optical designs. Some of the difficulties can be corrected with special lenses; others will have to be handled by taking special care in layout of the system.

Thick lenses

One of the largest discrepancies between theory and practice arises from the fact that the lens formula describes an unrealistic situation: it assumes that light bends sharply at a plane. In actual lenses, the thickness is a significant proportion of the focal length and light bends at each lens surface. Though the correction for this effect can be computed, the usual method is to measure the lens experimentally and determine new values for the lens so that the formula will still apply. Briefly, the method is this:

Assuming that light bends not at a single plane but at two parallel planes, first find focal point for each side of the lens by focusing parallel rays of light passing first one way, then the other way, through the lens. Repeat the procedure by focusing an object at a finite distance through the lens in both directions. Then from the lens formula, determine the effective focal length and the location of the two planes of apparent bending (principal planes). (For a complete description of this method, see *PE—July* '60, p 49.)

Aberrations

With actual lenses, points are never imaged as points, squares are never square, planes are not plane and all colors do not focus at the same point. In general, the larger the f-number of the lens, the worse these aberrations. The most common kinds of lens aberration are shown in the diagrams on opposite page.

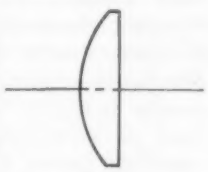
From these descriptions, it is clear that keeping all these conflicting defects in check is a complex mathematical job. In fact, it is impossible to design a practical lens that is free of all aberrations. Corrected lenses are designed by ray-tracing. The optical engineer computes the shape of the lens surface by following the path of light rays and noting their deflection as the rays pass from one medium to another. Ray deflection depends on angle of incidence, index of refraction and wavelength of light. Until recently, ray-tracing was done manually with six-place trig tables and precision layouts. But today, most of these problems can be solved on digital computers.

Though we normally think of a lens as being symmetrical, in practice such lenses occur only rarely. The reason is clear from the description of various kinds of lens aberrations—corrected lenses require special shapes and special kinds of glass and, often, special combinations of several lenses.

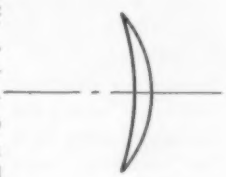
In controlling aberrations, the lens designer can vary the shape considerably without changing any of the basic lens parameters. Thus we can have a double convex lens, a plano-convex lens and a convex-concave lens—all positive, all 1-in. dia. and all with a 5-in. focal length. The difference is in the correction for aberrations. As far as the layout of the system is concerned, all these lenses can be treated the same. Despite the nonsymmetrical shapes you can still tell a positive lens from a negative one: positive lenses are thicker in the middle, negative lenses are thinner in the middle.

Special lenses

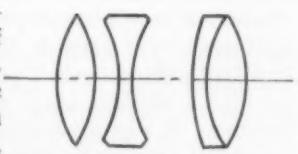
Here are some of the most common unsymmetrical and multi-element lenses. All these can generally be purchased as stock items. In the multi-element and eyepiece types, the several lenses can be treated as one lens. They are usually supplied mounted in a tube and, for purposes of layout, it is not necessary to know what's inside the tube—simply measure focal length and find principle points with the method outlined for thick lenses.



Plano-convex—flat (or nearly so) on one surface and convex on the other. They have less spherical aberration than double-convex lenses when the convex side faces the distant object. This makes them popular for condensers where point source of light is changed to converging rays. Condensers are usually made up of two plano-convex lenses with convex sides face-to-face and acting as a single lens.



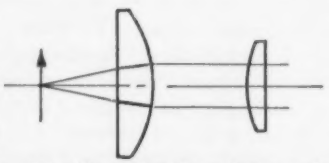
Meniscus lenses—thin, lightweight, having both centers of curvature on the same side. These lenses can be either positive or negative and are generally used with other lenses to reduce aberrations. With a meniscus lens, both principal points may be outside lens surface.



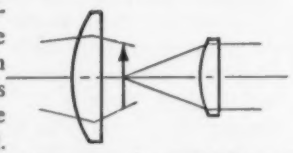
Multi-element lenses—made in a wide variety of shapes and configurations. Their purpose is to reduce aberration and give a sharp, brightly illuminated, undistorted image. In high-quality optical systems, nearly all lenses will be made up of more than one element. In some cases, separate elements will be cemented together; in others they will be separated by an air space.

Eyepieces—the basic eyepiece (also called "ocular") has two elements: eye lens and field lens. The field lens is so placed that the image to be magnified falls in plane of the field lens (in practice, the image is almost always placed slightly off this plane so that dust on the field lens will not be magnified along with the image). In this position, the field lens has little effect on the image—it neither magnifies or reduces it. Purpose of the field lens is to collect the marginal rays, which would otherwise be lost, and direct them into the eye lens. The eye lens magnifies the image by forming a virtual image

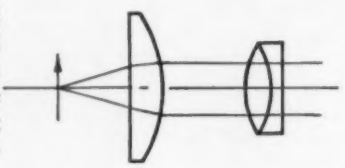
of the real image from the objective. The distance between observer's eye and the surface of the eye lens is called "eye relief." Standard tube OD for telescope eyepieces is 1.25 in.; for microscopes, 0.917 in. Here are the three most popular forms of eyepieces. Most eyepieces are simply variations of the Ramsden and the Huygenian.



Ramsden – probably the most popular because it is inexpensive and can be used with reticles because image plane lies outside the eyepiece tube. The Ramsden introduces only small amounts of spherical aberration, longitudinal chromatic aberration, distortion, and coma. Chief disadvantage: a rather large amount of lateral color.



Huygenian–greatest advantage is that it can be freed of lateral color–an important feature if it is necessary to compare size of objects being viewed. Other aberrations are generally greater than with Ramsden, except coma, which is essentially zero in both. Image plane lies between field lens and eye lens, so design is unsuitable for use with reticles. With short focal length (less than 1 in.) eye relief may be too short for comfort.



Kellner – modified Ramsden corrected for lateral color by a two-element eye lens. Retains most of the other advantages of Ramsden.

Lenses of unorthodox shape can be made up for special applications. For example, lenses need not be round–a semicircular lens (or even a pie-shape piece of a lens) will still form a complete image with some sacrifice in image brightness. If a partial lens is used, the cut edges should be masked or painted to prevent them from receiving light.

Selecting a lens

Without extensive experience in optical design, you can't hope to choose the right kind of corrected lens on the first try. Best you can do is follow these two rules: (1) inspect the optical instruments intended for an application similar to the one you have in mind and make note of the type of lenses used; (2) build a functional model of the system, using inexpensive lenses and replacing them with more expensive, corrected lenses when necessary. Good lenses cost money—quality of the lens is roughly proportional to its cost—so don't specify fancy lenses until you are sure you need them.

The best inexpensive lenses are those that have been removed from high-quality optical systems and sold as surplus—assuming your application is similar to that for which they were designed. Chipped or slightly damaged lenses sold as "seconds" can also be used. Several optical suppliers carry large stocks of inexpensive lenses, many costing less than $1 apiece. Two defects are common: (1) Optical axis not in center of lens. This throws image off axis and causes image to rotate with lens. (2) Axes of opposite curved surface not aligned. In effect, this puts image off-axis and increases aberrations.

Lenses are generally designed to work for specific distances of object and image. When choosing a stock lens, try to select one intended for magnifications of the same order as your application. Telescope lenses, for example, are designed for near-infinite object distances and usually, are unsatisfactory for close objects. If the catalog does not specify a recommended object distance or magnification ratio, it is safe to assume that the lens will be satisfactory for most general applications.

Coated lenses are usually well worth the slight additional cost. They pass more light because the coating kills reflections. These lenses are not a recent innovation. The principle was discovered more than 50 years ago when an experimenter found that tarnished lenses transmit more light then clear lenses. The coating on a lens, then, is simply an artificial tarnish. Coatings are usually designed to give minimum reflection in the middle of the visual spectrum, therefore they reflect some of the reds at one end of the spectrum and some of the blues at the other. The combination of these reflected colors causes the coated lens to have a purple cast.

When selecting lenses don't overlook plastic ones. They are less expensive, lighter and normally will pass more light than glass lenses. They are resistant to thermal shock, chipping and breakage, and can be drilled or machined for mounting. But because their surfaces are not as hard as glass, they are more easily scratched—the scratches will scatter light and fog the image. Lenses of materials other than glass or plastic may be required for special work. Quartz, for example, transmits light in the ultraviolet range down to 1800 angstroms, (glass usually cuts off at about 3500 A). Quartz also has a higher melting point than glass but is optically inferior in some other respects.

Mirrors and prisms

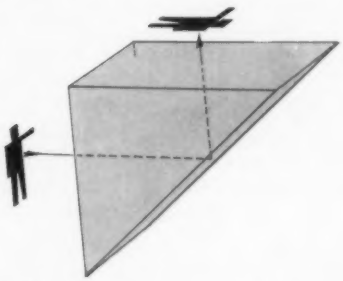
Curved mirrors can serve in place of lenses to form images but in most optical systems of interest to the design engineer their disadvantages outweigh their advantages. These mirrors are found chiefly in large astronomical telescopes and as reflectors for forming parallel rays from a concentrated light source. Ideally, such a curved mirror should have a parabolic surface so that parallel light rays will focus at a point. But spherical mirrors are easier to make and therefore less expensive; their spherical aberration is generally not too objectionable if the focal length is long.

Mirrors are generally less expensive than equivalent lenses, particularly those of larger diameter, and there is no problem of chromatic aberration. But the reflecting

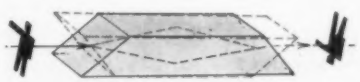
Text continued on page 72

Some common prism shapes

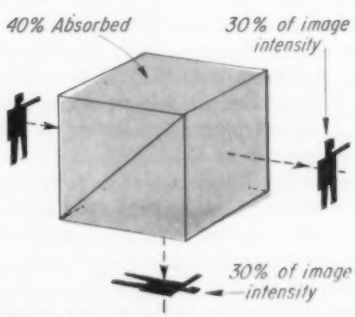
WEDGE—deflects light path through small angle (usually less than 0.3°). A two-element wedge will be needed to correct for chromatic aberration if deflection angle is large.



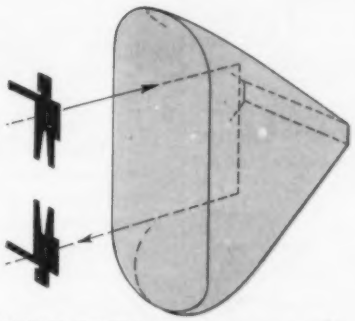
RIGHT-ANGLE PRISM—turns light path through 90° and reverses the image in one dimension.



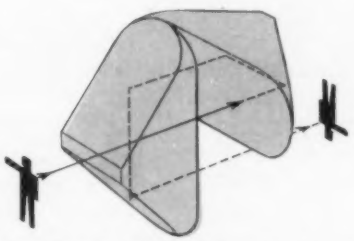
DOVE PRISM—reverses image in one dimension. Must be used with parallel rays of light. With converging light, aberration may be excessive. When dove prism rotates about its axis, image rotates twice as fast. This feature is sometimes exploited to keep hand-held camera horizontal; a dove prism in the view finder exaggerates apparent tilt angle of camera.



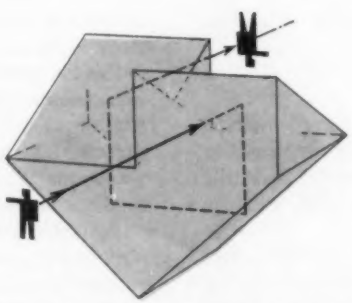
BEAM-SPLITTER—usually made of two right-angle prisms cemented together with hypotenuse partly aluminized. Generally, about 30% of light is deflected both directions and remaining 40% is lost.



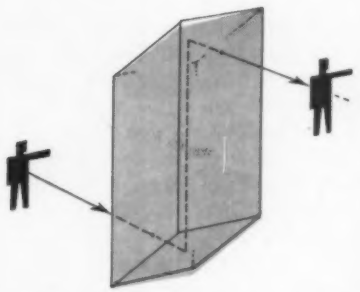
PORRO PRISM—simply a narrow right-angle prism used to turn light path 180°. Reverses image in one dimension. It is used in binoculars to erect image of objective lens. Generally it is combined in one of the following two ways:



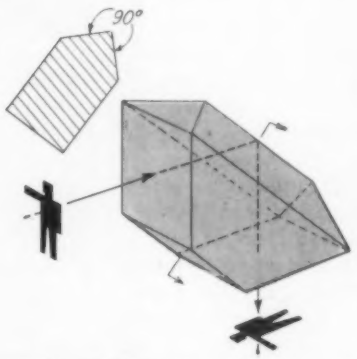
Porro prism of first type—two porro prisms cemented together at right angles. Reverses image in both dimensions. Light path is not deflected but is displaced.



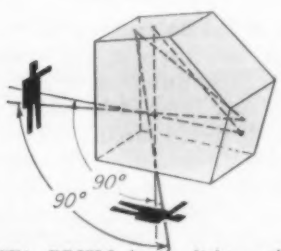
Porro prism of second type—porro prism with two right-angle prisms cemented to hypotenuse. Has exactly same effect as first type but is more expensive and slightly more compact.



RHOMBOIDAL PRISM—laterally displaces light path without reversing image. Same effect as two 90° prisms without light loss at intermediate faces.

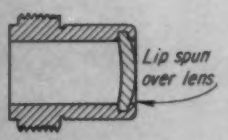


AMICI PRISM—right-angle prism with "roof." Bends light path 90° but roof reverses image from left to right. Because images are formed on top of each other, roof must be exactly 90° or there will be a double image. This can be corrected, but not very economically, by using only left half of entrance face and right half of exit face (or vice versa).

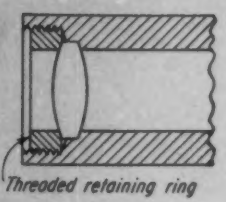


PENTA PRISM—bends light path 90° (without reversing image) regardless of approach angle of incident rays. Both reflecting surfaces must be silvered because angle of incidence is not large enough to permit total reflection.

Typical lens mounts

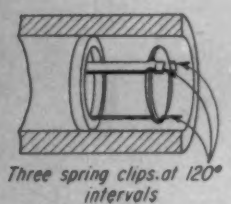


Lens butts against shoulder of cell and is held in place by spinning lip of cell over end of lens. Lens must be a close fit in the cell. This design is particularly suited to eyepieces and interchangeable lenses.



Threaded retaining ring holds lens in place but allows it to be removed for cleaning. Alternatively, lens can be held with a press-fit ring though it cannot be removed as easily.

For vibration and shock resistance, spring-loaded mount uses two intertwined springs and a loose-fitting ring. Lens is held in place with a circular retaining spring, which snaps into internal groove in the housing.



Condensers and other lenses exposed to heat are often mounted this way. Accurate positioning is difficult, but it allows glass to expand and exposes maximum lens surface to cooling air.

coating is exposed to air where it can tarnish and the optical system is generally more complicated than an all-lens system.

Bending the optical path

Prisms and flat mirrors allow you to vary the geometrical arrangement of your optical system. With prisms you can bend the light path to avoid obstruction, you can make the system more compact by folding the light path, and you can create special effects.

A simple prism serves the same purpose as a flat mirror but prisms have several advantages. The silvered surface of a mirror reflects only part of the light—about 82% of the blue, 92% of yellow and 98% of the long infrared. Moreover, if the mirror is silvered on the back to prevent tarnishing (called a "second-surface mirror"), there will be annoying double reflections and an additional 8% of the light will be lost when light enters and leaves the glass. (Loss of light by absorption is usually negligible.)

Mirrors have only two advantages: They are less expensive than prisms, and can be positioned to give any angle of deflection (prisms can be made for any angle too, but stock units are usually 90°, or 180°).

Prisms can cause aberrations just as lenses do. However, because these are frequently opposite to the aberration of a lens, they are sometimes used to counteract lens defects. Like lenses, prisms can be coated to reduce surface reflection. A variety of typical prisms are shown in the sketches on the previous page.

Besides prisms, there are other devices that help the designer solve special problems in his lens system. The beam-splitter is one of these. In simplest form it is merely a semitransparent mirror, set at an angle to the light path so that part of the rays are reflected at an angle while other rays pass through. Beam-splitters are also made by cementing two right-angle prisms together at the hypotenuse to form a prism with a square cross-section. Whatever their form, the splitters are not every efficient, often absorbing as much as 50% of the light. A typical one will pass about 30% in each direction and absorb the remaining 40%.

Also useful is the reticule. It can be purchased ready-made in a variety of patterns or can be made by etching, engraving or photographically printing a pattern on a glass disk. Reticules are useful for comparing or measuring the size of an image. Mount them so that they lie in the plane of a real image; this way they are seen as if superimposed on the object. It is important that the glass surface be kept free of dust and scratches—anything that lies in the plane of the image will be visible to the eye.

SPECIAL CONSIDERATIONS

If the design of your optical system depends on magnifying very small objects, remember that the resolving power of any lens is limited. Even with a perfect lens, a point source of light is imaged as a bright disk surrounded by alternate dark and light rings; the central disk contains about 84% of the light. If two object points subtend too small an angle at the lens, their image disks will overlap and the two points will look like one. The limiting angle depends on diameter of the lens and the wavelength of light. If we assume a wavelength in the middle of the spectrum ($\lambda = 550$ angstroms), the limiting angle, θ, (in seconds of arc) is

$$\theta = \frac{5.5}{d}$$

where d is lens diameter in inches.

It is often necessary to provide elements that prevent the passage of certain rays of light. These elements are called stops. In general, there are three types:

1. **Aperture stops** limit the amount of light entering the system. They control image brightness and are usually placed close behind the objective lens. An aperture stop does not limit the field of view; that is the function of a field stop.

2. **Field stops** are mounted in the plane of a real image in the system. They eliminate undesirable rays through edge of the field where aberrations are greatest and also serve to focus viewer's attention on the image at center of the field.

3. **Glare stops** prevent stray light from passing through the system, improving image contrast. They are usually placed at the point where the image of the aperture stop would fall. The diameter and exact placement of stops are determined by ray-tracing.

For most of the optical devices you would design, mechanical design will be determined by the particular requirements of the over-all system and will be handled the same way you handle a mechanical system. Mounting of optical parts, however, is a special problem and requires special attention. It is good practice to mount the lens in a small ring or tube, which is then screwed or clamped in the instrument. This allows accurate location, ensures that lens is properly centered and that the plane of the lens is perpendicular to the optical centerline. Also it provides means for adjustment. Brass is one of the best materials for such lens cells. It is soft enough to be worked and is better than aluminum for threaded parts because it does not gall. Multi-element lenses are usually supplied mounted in cells.

Typical lens mounts are sketched in the facing page. Notice that it is easier to locate a lens if it has one flat surface. Inexpensive mounts can also be made by bending tabs from the side of a tube or by cementing the lens in a tube. But because these methods are much less accurate, they are not recommended for most systems.

Mountings for prisms and mirrors, like lens mounts, should be made by first attaching the element to a flat piece of metal or suitably shaped casting, which is then clamped or screwed in place. Accurate location of prisms is just as critical as that for lenses—a slight misalignment of the prism can shift the optical axis and throw the entire system out of adjustment. Prisms can be mounted in a subassembly with clips or tabs or they can be cemented into a close fitting holder with an epoxy. All inside surfaces along the optical path should be painted flat black to reduce reflections and scattered light.

LAYING OUT YOUR SYSTEM

You can lay out an optical system much the same as you would a mechanical system. Begin with the requirements and make a rough sketch of the elements and the location of each. To start with, assume the system is a straight line—you can fold the light path where necessary after you have settled on a preliminary design.

You have a number of variables to manipulate. Over-all size of the system is probably already fixed by the design of the machine but you still have to settle on magnification, object distance, focal length, illumination, and lens diameter. The following equations will help establish some of these variables. Rough over-all size, R, is

$$R = L + L' = L(M + 1)$$

and from the lens equation

$$R = \frac{L^2}{L - F} = \frac{F(M + 1)^2}{M}$$

The equations apply only to single-lens systems—for more elaborate systems compute individual R's and add them together.

Magnification is often the most important factor. From magnification and over-all size you can compute the focal length. Then the needed illumination ratio will tell the diameter of the lens.

With these computations and a rough sketch as a guide, make a scale drawing that shows object, lens and image locations. Include prisms and stops where needed. Trace the principle rays through the lenses to show the lateral dimensions of the system. When tracing rays, observe these two rules: (1) rays parallel to the optical axis bend at the second principle plane of the lens and converge on the focal point; (2) rays through center of the lens are not deflected.

Remember these two precautions when planning your preliminary layout:

- Objects should be positioned perpendicular to the

text continued, page 75

SIMPLE OPTICAL SOLUTIONS TO

Example 1

■A vernier scale inside a nuclear reactor must be monitored by an operator. Because of radiation, the scale cannot be viewed directly and because of heat, a reliable electrical or mechanical servo system would be expensive to install. Design an optical system that will allow the operator to see the scale as if located 1 ft from his eye.

The optical path must be bent as shown below to avoid structural member inside the reactor. Total distance to the scale is 24 ft, so magnification needed is 24/1 = 24. From a catalog of inexpensive lenses, a corrected objective is found with focal length of 45 in. and diameter 3 in. With a corrected eyepiece from the same catalog (focal length = 1.25 in.) the magnification will be

$$M = \frac{F_o}{F_e} = \frac{45}{1.25} = 36$$

Though this is more than needed, the additional magnification will do no harm.

First, lay out the system in a straight line, ignoring for the moment the bends in optical path. Because of the extreme difference between the vertical and horizontal dimensions, it is almost impossible to make a scale layout. Even a scale drawing of just the system, objective lens and eyepiece, will be difficult. And exaggerating the vertical dimensions is little help; such exaggeration changes all the important angles. It is for this reason that it is better to compute the size of the extreme rays at points of interest and draw the elements in these areas.

Assuming thin lenses, place the objective and eyepiece so that their focal points coincide. Locate the eyepiece at a point slightly less than twice its focal length from the operator's eye. It will be necessary for the operator to see the full length of the 1-ft scale, therefore, the field angle will be

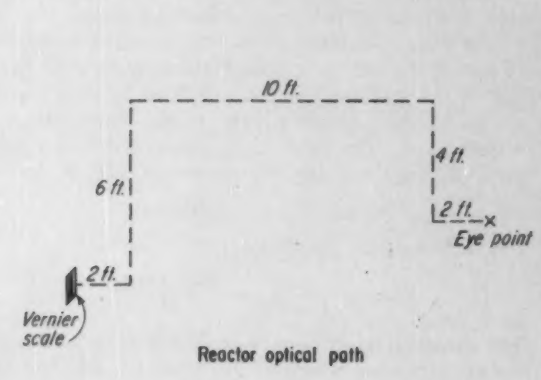
$$\text{tan of } \tfrac{1}{2} \text{ angle} = \frac{0.5}{20} = 0.025$$

The lenses chosen will easily cover this field. Further, the scale marks are relatively coarse, so resolution will be no problem.

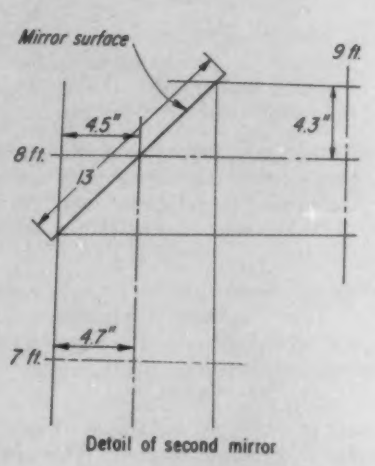
From the layout it is apparent that the reflecting surfaces will all have to be quite large and, in the case of the one closest to the scale, larger than 1 ft. Mirrors are the only answer in these circumstances. First-surface mirrors are best to keep light loss and double-reflection to minimum.

When the lenses arrive, measure their principal points. From these measurements make an accurate layout, still working with a straight-line optical bath. Draw mirrors at 45° (for right-angle bends); compute size from distance between extreme rays as in sketch below.

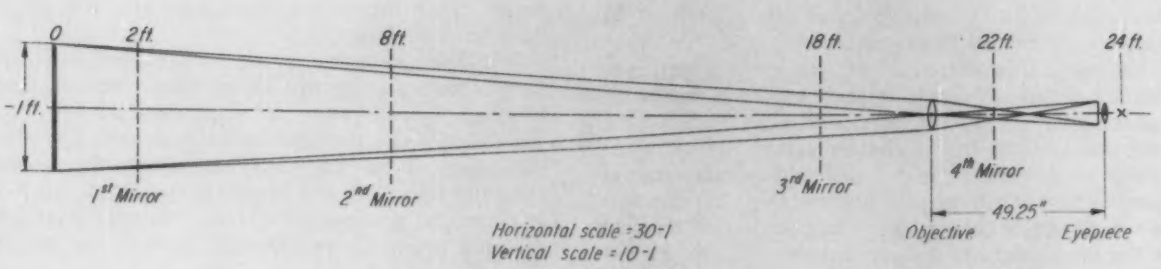
Draw final layout to show system with 90° bends and full-size, detailed lens and mirror mounts. An enclosure around the optical path will not be necessary in this case unless there are other sources of light in the system. Nearby reflecting surfaces, however, should be painted flat black. Make eyepiece mount adjustable to accommodate for different eyes and correct for small layout errors. Test a mockup of the system before installation.■



Reactor optical path



Detail of second mirror



Optical system

Example 2

■ Design a system to count parts as they pass on a conveyor belt. The parts, are ☆ in. dia and ½ in. long, are oriented on the belt with long dimension perpendicular to direction of travel. Mechanical counting is not practical; the parts are too small and too light to be detected by feelers and there is no way to count the parts when they are handled before or after they pass on the belt. Nor can they be counted by passing light through the belt (it is opaque) or across the belt (other machine elements interfere).

An over-the-belt optical counter seems to be the most practical answer. Light shines on the belt and part, and image of part is reflected through a lens into a photocell. This method will also allow the counter to discriminate between different colored parts (different reflectivity) and reject off-color parts, if that is desirable. The counter will have to fit in a space between 12 in. above belt (where machine elements interfere) and 2 in. above belt (minimum clearance allowed by production engineer).

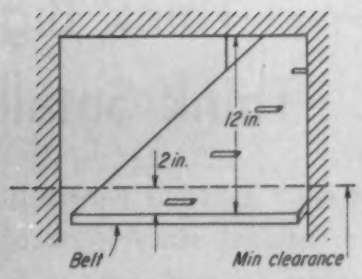
Choose a lens with small *f*-number and focal length greater than 2 in. A catalog of lenses shows a 1.45-dia lens with 2.60 focal length. This gives an *f*-number of about 1.8, which should be adequate. With a photocell that has an active area of ¼ in. sq, magnification will have to be ¼ ÷ ☆ = 2 to achieve maximum output. Assuming a filament light-source, make a preliminary layout of the system, using the same lenses in both the light-focusing and image-forming parts of the system.

Start with the image-forming system and compute lens and photocell position for the needed magnification.

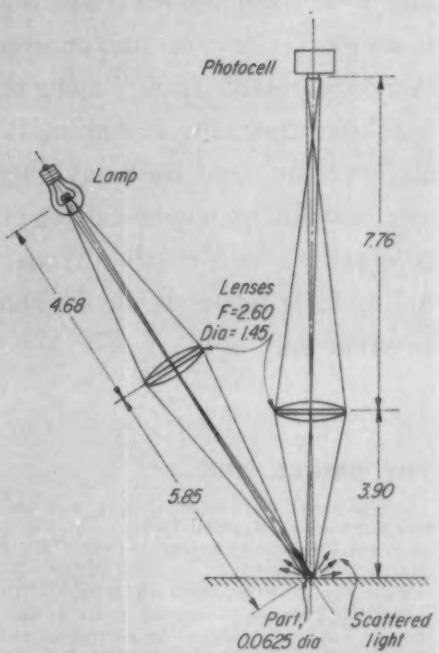
$$L = F\left(\frac{M+1}{M}\right) = (2.6)\left(\frac{3}{2}\right) = 3.90$$

Similarly, image distance will be 7.76 in. Then, working with light-focusing side of system and assuming a filament 0.050 in. wide, magnification will be 0.062/0.050 = 1.25, and distance between light source and the lens will be 2.6 (2.25/1/25) = 4.68 in. Image distance is 5.85 in. The graph on page 67 can be used to compare the illumination of alternative lens system.

When the lenses arrive, find the principal points and make an accurate layout. Test the system, using the actual parts and a background with same reflectivity as belt. Several corrections may be necessary: The threshold level of the photocell may need to be adjusted; the lamp may not be bright enough; a shield around the photocell may be needed. When the system operates reliably, make detail drawings of the lens mounts, lamp holder, photocell mounting, tubes, shields and other mechanical parts.■



Parts to be counted



Optical counting system

optical axis. Nonperpendicular objects projected on an equally nonperpendicular screen will not be uniformly magnified. Or if their image is projected on a perpendicular surface, parts of the field will be out of focus when other parts are in focus.

• Place objects close to the optical axis wherever possible. Avoid layouts in which light rays enter the lens at large angles to the optical axis—aberrations such as coma, astigmatism and lateral color are generally greater under these conditions.

When you've worked out the preliminary design to your satisfaction, purchase the lenses and find their principal points and focal lengths according to the procedure for thick lenses. Draw a precise layout and trace the rays through the system to be certain that the optical elements are properly placed and that there are no obstructions in the path of the rays.

You may want to make several experimental models of the system before settling on a final design. If the model has some defects you may be able to cure it with better quality components or simply by adjusting the location of a critical part. If there are serious difficulties, it is probably best to call in an optical consultant. But avoid calling him too early—many of the design problems you face are not optical but mechanical and do not concern him. Settle on the mechanical system and the rough optical system before you turn the problem over to an expert.

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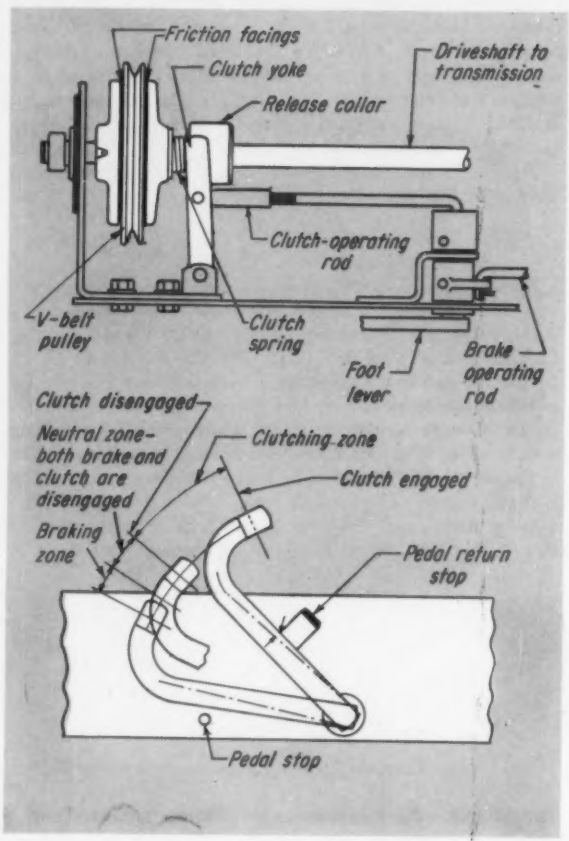
assignment:

. . . Think Big
. . . Think Small

But don't split our personality. That was International Harvester's order when it asked its designers for a still bigger tractor and a still smaller one. The double result is shown on our cover and analyzed on these two pages. Aside from sharing the I-H look, both machines aim at making it easier for the operator. One, for today's big-scale farmer, is a 300-hp, 4-wheel-drive giant openly competitive with crawler types; the other, a 7-hp little fellow, is for the homebody out in suburbia.



THE SMALL ONE

International Harvester already had its 13-hp Cub, a handy machine for small farms. But the company asked its Farm Equipment Research Center for something still smaller. Here's why:

With the growing trend to suburban living, half the population increase in coming years is expected to be in open or "urban" country—an estimated increase here of 32 million by 1975. This market needs a comfortable, durable, lawn or garden tractor smaller than a conventional farm tractor, but more powerful than a riding mower—yet with equal simplicity in design and handling.

Requirements set up for the Cub Cadet late in 1959 called for a 7-hp tractor with three forward speeds and reverse in an enclosed transmission giving a maximum ground speed of 6 to 8 mph. Controls were to be simple, foolproof and low cost. Variable-ratio steering was needed for easy control in normal driving but fast response for quick turns. The tractor had to be comfortable and look like a tractor.

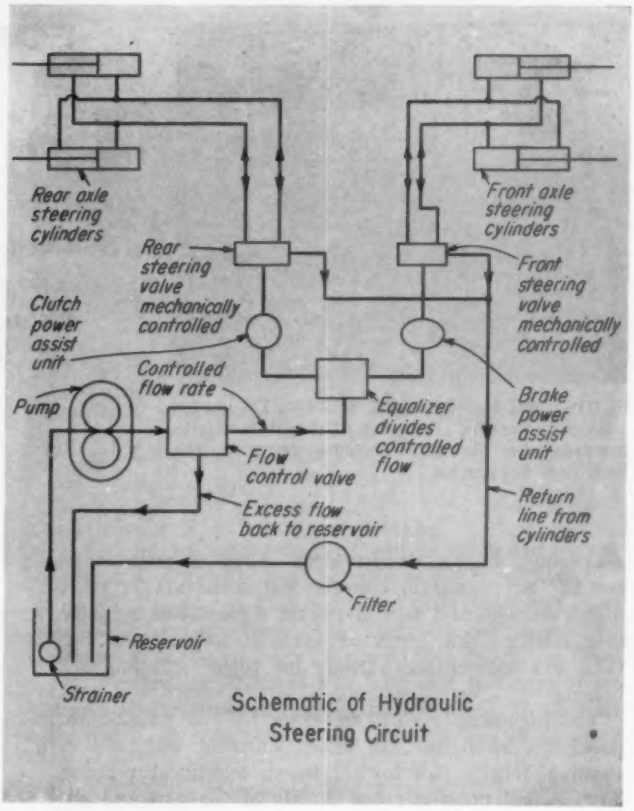
Appearance considerations were brought in during early development and several design prototypes were worked out during 1960, with appearance guided by the stylists' concept. The first tool-made tractors were turned out late in 1960.

Transmission selected is the production unit in use on the 13-hp Cub, with input ratio modified to give desired ground speed with a 3600-rpm engine. Rear wheels are mounted on sides of transmission case; the hitch bolts on rear of the case and seat on top; frame for engine and front axle mounts on front of transmission.

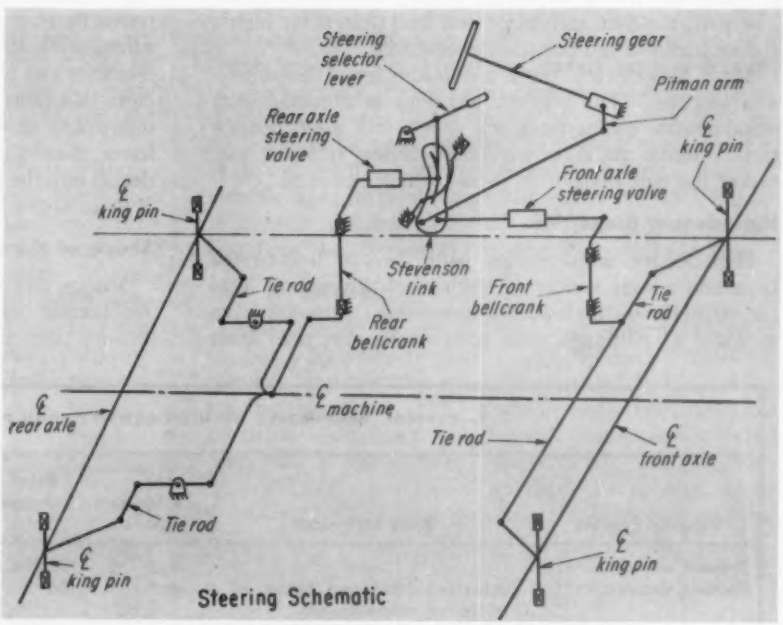
Drive from the Cadet's 7-hp engine is by V-belt, with the driven pulley incorporated in a novel clutch. One foot pedal on the left side combines clutch and brake; initial pedal movement disengages clutch, remainder of travel applies brake.

For operator comfort, engine is mounted with flywheel and cooling blower at rear and muffler at front, so cooling air is blown out the front. Starter switch, throttle, choke and ignition switch are on control panel under the wheel. Steering is through a barrel cam on the steering rod moving a pitman arm and drag link to a conventional tierod assembly. Cam contour gives a slow ratio straight ahead with a faster ratio on either side.

Hood lifts at rear, pivoting at grille to give access to fuel tank and 12-v battery. Starter-generator is driven from the front end of the crankshaft, which also serves as a power takeoff for implements.



Schematic of Hydraulic Steering Circuit



Steering Schematic

THE BIG ONE

International Harvester has become increasingly aware that significant changes in agriculture are opening new markets for larger tractors. Average farm size is increasing, calling for increased tractive effort and higher speeds. Furthermore, irrigation and improved methods are opening large areas in low-rainfall climates with dry firm soil—here a 4-wheel rubber-tired drive provides adequate traction and contact area, permitting higher speeds than obtainable with crawlers.

Requirements given engineers at the F G Hough Co (I-H subsidiary) were to develop a 15-ton, 180-drawbar hp, 4-wheel drive-and-steer tractor with an air-conditioned cab, using a new I-H 817-cu in. turbocharged diesel developing over 300 hp. Operator effort had to be reduced to a low level, but with no loss in maneuverability. This called for power operation of clutch, brake and steering.

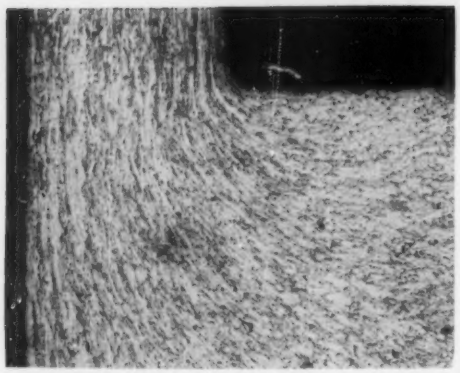
Time lapse from formation of the project group to construction of the first prototype was only nine months. Field demonstrations were made in Sep 1960, and first limited production run is scheduled for May 1961.

Major design problems were in powering the steering and controls, and in developing the transmission and rigid frame.

Hydraulic power for operating brakes, clutch and steering is supplied by an engine-driven pump delivering 55 gpm at 1200 psi. System is designed to give 15-gpm preference to the steering system. Steering drive to each wheel is mechanical for synchronization, with mechanical selection of front-wheel, four-wheel or crab steering hookup; hydraulic power amplifies manual steering effort.

Transmissions available lacked the wide speed range needed; creeping speeds, closely grouped series in the working range, and high speeds for road travel. A new transmission was developed with ratios giving 6 forward speeds in the range of 3.5 to 7.5 mph, and 14 and 23 mph (with engine governed at 2100 rpm) plus four reverse speeds of 2.7, 3.2, 3.7 and 11.3 mph. A torque converter reduces shock loads on gearing and provides torque amplification, but can be locked out if desirable.

For operator comfort, cab is dust-tight, positive-pressure ventilated by a blower and dry filter, and provided with a heater and an air conditioner.



FLOW LINES INCREASE STRENGTH across change in section. Ductility of the high-density metal-powder part allows cold-working for the improved properties.

FOR STRONGER, TOUGHER METAL-POWDER PARTS

Sintered iron powders with densities over 90% can do jobs formerly restricted to wrought or cast metals. The process gives greater accuracy with less machining; finished parts are therefore cheaper despite higher material costs.

FELIX GIORDANO, *regional editor (Detroit)*

Although higher density costs more, it offers these benefits not found in conventional metal-powder parts: higher strength and ductility, better dimensional accuracy, finer surface finish, increased resistance to wear and abrasion, and less surface porosity for better soldering and brazing.

The high-density parts are made by first pressing the powder at 50-60 tons per sq in., sintering, and then increasing density still further by an additional pressing. This second pressing raises density of the part and also improves its dimensional accuracy. The die burnishes the part as it is ejected, improving surface finish at the side. The parts are then carburized and heat-treated for higher surface hardness and better wear-resistance.

Most high-density parts are made from electrolytic-iron powders. The graphite additions in normal-density metal-powder compositions are usually not used, because carbon forms an alloy with iron during sintering and makes the part difficult to press to high densities.

High-density properties

High-density metal-powder parts can be heat-treated to obtain a wide variety of mechanical properties. Tensile strengths for high-density iron-powder parts are given in Table I. Although these parts are stronger than lower density ones, this alone is not enough to justify the increased cost. For example, tensile strength can be more cheaply attained by adding copper and graphite to the powder mix and pressing to a normal density (70 to 85%). However, graphite in the mix makes such a part difficult to wet in soldering or brazing.

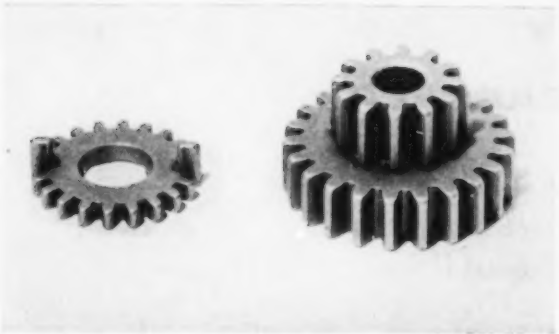
High-density parts also have high ductility (up to 25% elongation), better toughness and impact resistance, and a dense structure without interconnecting pores. When the density is increased to over 93%, the resulting closed pores reduce flux entrapment during soldering and brazing. This produces more reliable joints because corrosive fluxes are easily removed. Closed pores also aid adhesion of electroplates and give a definite carburized case with soft core. This sharp definition is needed in thin parts that must be hard at the surface to resist wear, and soft inside to withstand impact. In contrast, a density lower than 92% allows carburizing gases to penetrate deeply into the part; this hardens the entire part and makes it more brittle.

Shape of the part

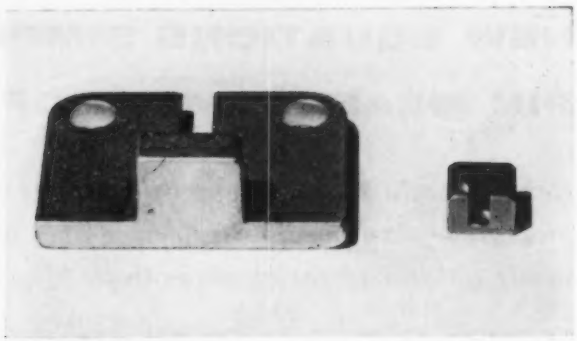
Shapes and sizes of product are more restricted than for normal metal-powder densities. While most high-density parts are thin, with thickness less than width or

I—TYPICAL PROPERTIES OF HIGH-DENSITY IRON-POWDER PARTS

Powder Process	Heat Treatment	Density gm/cc	Relative Density, %	Tensile Strength, psi X 1000	Yield Strength, psi X 1000	Elong., %
Pressed, sintered	none	6.8–7.3	86.5 to 93	28 to 38	20 to 24	7 to 10
Pressed, sintered	Carburized, hardened, tempered at different temperatures	6.8–7.3	86.5 to 93	50 to 62	———	1.0
				65 to 78	———	0.5
				75 to 95	———	0
Pressed, sintered coined	none	>7.5	>95	54 to 59	52 to 56	4 to 8
Pressed, sintered, coined, resintered	none	>7.5	>95	45 to 49	29 to 31	14 to 25
Pressed, sintered, coined, resintered	Carburized to different case depths, hardened, tempered at different temperatures	>7.5	>95	90 to 100	78 to 86	2 to 4
				132 to 138	110 to 120	1 to 2
				160 to 170	157 to 165	1
				190 to 200	190 to 200	0 to 1



PARTS WITH THIN PROJECTIONS or two diameters can be made to densities about 90% if not re-pressed.



LARGE DIFFERENCES between thick to thin sections limit densities in these parts to about 95%. However, this density is sufficient to improve soldering properties.

diameter, maximum thickness can be as high as 4 times the width. Density is higher at punch faces in these thick parts, because the powder does not transmit pressure uniformly and tends to stratify.

Parts with two diameters are not recommended if required density is over 90%. They tend to form a weak plane at the common cross-section when re-pressed. Large changes from thick to thin sections also hinder re-pressing and are difficult to make with density over 95%.

There are no limitations on hole shape, but diameters smaller than $\frac{1}{16}$ in. are impractical. Holes parallel to the punch axis should have a depth less than 4 times their diameter and be at least $\frac{1}{16}$ in. from any edge.

Chamfers should be less than 45° to the punch face and end in a shoulder at least 0.005 in. from the edge to avoid feather edges on the punch. Radii have no minimum-size limitation, but like chamfers should not extend to the sides of the parts.

Dimensional tolerances are generally better than those of normal-density parts because coining sizes the parts. Also, carbide dies, which must be used, have low wear. Die wear often is as low as 0.0005 in. for production runs of several million pieces. This gives consistent dimensions from part to part and even for interrupted press runs. Dimensional tolerance and surface finish that can be expected from high-density metal-powder parts are given in Table II. Sometimes, the surface finish that can be obtained by re-pressing is enough to justify the process because it eliminates need for grinding and polishing.

Maximum part size depends upon press capacity. Most high-density parts have been made on 50-ton presses, which can produce a cross-section up to 1 sq. in. In these parts, maximum length is 3 in. and max thickness about $\frac{3}{4}$ in. High-density parts generally require 50 to 60 tons per sq in. of section, with the higher pressures required for more intricate parts.

II—WHAT YOU CAN EXPECT IN HIGH-DENSITY PARTS

Tolerance on these dimensions	
Thickness—up to 0.100 in.	0.0015 in.
0.100 to 0.375	0.002 in.
over 0.375 in.	0.004 in.
Radius	0.001 in./in.
Circumference	0.0005 in.
Radial locations	0.0005 in.
Concentricity—(total indicator reading)	0.001 in.
—between holes 3/16 or larger	0.0015 in.
Surface finish on die and core surfaces	8 to 10 microin.
on punch surfaces	12 to 18 microin.

Cost comparison

Carbide tooling for high-density metal parts is expensive. As a general rule, high-density parts don't pay off until production quantities approach 10,000 pieces and part shapes become more intricate. However, many short runs of high-density blanks are economical even though quantities are not large enough to justify an intricate die. Blanks for small precision gears are a good example. It is impractical to press in the fine tooth form. But it is possible to form blanks (accurate within ±0.0005 in.) by re-pressing, and machine them to finished gears at less cost than that for machining directly from solid bars.

How to specify

Although the process is being used with a variety of materials, high-density parts of iron powders are the most common and are the only ones covered by an ASTM specification (B309-58T). Even this specification is still tentative. Additional industry-wide standards are being prepared by the Powder Metals Parts Manufacturers Association, but until such standards are adopted, specifications of individual manufacturers are the only available guides.

EDITOR'S NOTE: For additional design data on sintered-powder parts, see these articles:

Guide to Specifying Metal-powder Parts, July 25 '60, p 56—When designing with metal powder, how much the part costs will depend not only on the kind of powder but on how much porosity you can tolerate.

Powder-metal Process and Part Design, Mid-Oct '55, p D-14—Influence of shape, size, tolerances and mechanical properties on selection of a metal-powder process.

NEW EQUATIONS SIMPLIFY PIN MEASUREMENT OF GEARS

Here are explicit formulas for calculating over-pin or between-pin measurements of ideal tooth forms. They also establish measurements for desired variations in tooth or space thickness.

JOHN H GLOVER, *product design engineer, Ford Motor Co, Detroit*

Any good machinist's handbook includes tables which, with some calculations, provide nominal values of over-pin measurement of external gear teeth or between-pin measurement of internal gear teeth. The equations on which these tables are based are also well known, but their disadvantage is that they do not easily solve for minor variations in tooth form. Further, they use terms relating to the theoretical tooth-form parameters rather than those that usually appear on the drawing.

Transformation of these formulas into more convenient terms, plus an extension of the relationships to include variations of tooth or space widths, solves both problems. It becomes possible to set up a combination reference and work sheet giving all the necessary equations and including spaces to be filled in a relatively routine way, leading to a quick, easily checked answer.

The equations

The formulas apply to spur, helical, external or internal gears. Since the spur gear is a special form of the helical gear (with helix angle equal to zero) the general equations (1) through (7) apply to either.

For internal gears, either tooth or space thickness may be specified, and this is taken care of by using Eq (2) when tooth thickness is specified, and Eq (3) when space thickness is specified.

The measurement M usually corresponds to a low and high limit for tooth or space thickness, and this requires two values for inv ϕ_s. The simplest way to obtain them is to substitute $t_{n\,min}$ or $s_{n\,min}$ from drawing specifications in Eq (2) or (3) to obtain inv $\phi_{s\,min}$. Then, inv $\phi_{A\,max}$ = inv $\phi_{A\,min}$ + Δinv ϕ_A, calculating Δinv ϕ_A from Eq (4) or (5).

REFERENCE EQUATIONS

Basic relations:

$$\tan \phi_t = \tan \phi_n \sec \psi \qquad (1)$$

inv ϕ_t = ... (from tables)

$$\text{inv } \phi_t = \tan \phi_t \pm \left[\frac{(d \sec \phi_n + t_n) P_n - \pi}{N}\right] \quad \begin{matrix}\text{External} + \\ \text{Internal} -\end{matrix} \qquad (2)$$

$$\text{inv } \phi_A = \text{inv } \phi_t - \left[\frac{(d \sec \phi_n - s_n) P_n}{N}\right] \quad \text{Internal} \qquad (3)$$

For tolerance analysis:

$$\Delta \text{ inv } \phi_A = \pm (\Delta t_n) \frac{P_n}{N} \sec \phi_n \quad \begin{matrix}\text{External} + \\ \text{Internal} -\end{matrix} \qquad (4)$$

$$\Delta \text{ inv } \phi_A = (\Delta s_n) \frac{P_n}{N} \sec \phi_n \quad \text{Internal} \qquad (5)$$

$$\Delta \text{ inv } \phi_A = \pm (\Delta d) \frac{P_n}{N} \sec \phi_n \quad \begin{matrix}\text{External} + \\ \text{Internal}\end{matrix} \qquad (6)$$

Master equation:

$$M = \cos\left[(\Delta N)\frac{90}{N}\right] D_b \sec \phi_A \pm d \quad \begin{matrix}\text{External} + \\ \text{Internal} -\end{matrix} \qquad (7)$$

WORKSHEET

Gear Part No. X-1000 External ✓ Internal ____

N 40 ϕ_n 20 deg P_n 10 d 0.1750

t_n 0.1594 / 0.1564 ϕ 30 deg s_n ____ D_b 42.580

tan ϕ_t = 0.36397 × 1.1547 = 0.42028 inv ϕ_t = 0.022442

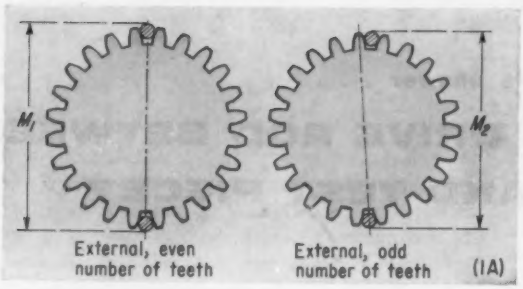
inv ϕ_A = [0.029533 / 0.029533] + 0.002 × 10/40 × 1.1547 = 0.030399

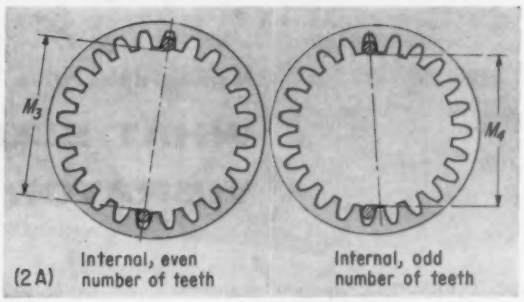
sec ϕ_A = [1.1023 / 1.1044]

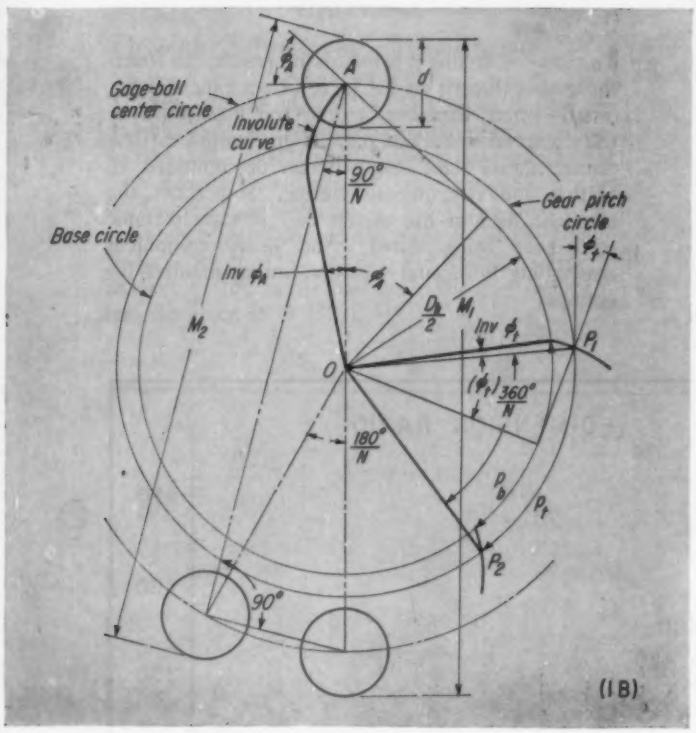
M = 1 × 42.580 [1.1023 / 1.1044] + 0.175 = [47.3696 / 47.3775]

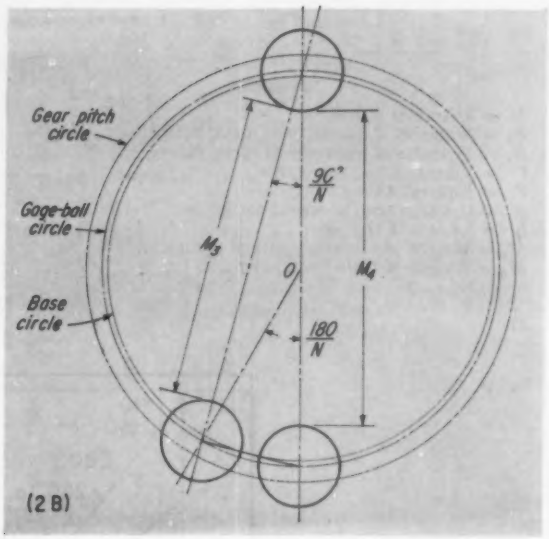
SYMBOLS

- D_b — Base diameter of the gear
- d — Pin or ball diameter
- M — Measurement over two pins or balls for an external gear or between two pins or balls for an internal gear.
- P_n — Normal diametral pitch ($P_n = \pi_n / p_n$)
- N — Number of teeth in the gear
- p_b — Base circular pitch
- p_n — Normal circular pitch
- p_t — Transverse circular pitch
- s_n — Normal space thickness measured on the pitch cylinder
- t_n — Normal tooth thickness measured on the pitch cylinder
- Δ — Symbol prefix indicating a change from a previously assigned value
- ΔN — Least increment in N to obtain an even integer. (By this definition $\Delta N = 0$ if N is even, and $\Delta N = 1$ if N is odd)
- π — 3.14159
- ϕ_A — Pressure angle at a gage ball center, in a transverse plane of the gear passing through both ball centers (Fig 1). A gage ball may be a measuring ball or an imaginary ball inscribed in a pin of the same diameter — pins being used for the actual measurement.
- ϕ_n — Normal pressure angle at the pitch point
- ϕ_t — Transverse pressure angle at the pitch point
- ψ — Pitch helix angle









Eq (6) is used to calculate Δinv ϕ_A in terms of d, and is useful when original pin or ball is unavailable.

The final equation (7) is a general one in which N may be either odd or even; this is in contrast to other similar equations. Geometrical relations are shown in diagrams. Use of the discriminating factor ΔN ensures that the odd numerical factor cos 90/N will be used only for odd-numbered teeth. When two separate equations are used for odd and even numbered teeth, there is always the possibility of having an error introduced by using the wrong equation. For interchangeability of pins or balls in Eq (7) two conditions must be met: The gear must be external, and if it is helical it must have even number of teeth. If these conditions are not fulfilled, the measurements must be made with balls only.

DEFINITIONS

Pressure angle in a given plane at a point on an involute is the angle between the profile normal at the point and the normal to the line drawn from the point normal to the axis.

Involute function of the pressure angle (invϕ), so-called because it is equal to the tangent minus the angle itself expressed in radians, is the polar angle subtended between the origin of the involute curve at the base circle and the point on the involute curve where the pressure angle is measured.

Circular pitch on a gear is the distance on the pitch cylinder measured in some definite direction from a point on the profile of one tooth to the profile on the same side of an adjacent tooth—p_b and p_t in Fig 1(B). Geometry for internal gears, Fig 2(B), is analogous.

Central angles ϕ_A and ϕ_t are equal in magnitude to the pressure angles at A and P_1, but are more properly called **profile angles.** The angle ϕ_A at A is the definitive transverse pressure angle at a point A on the involute helicoid.

EDITOR'S NOTE: For additional information on pin measurement and design factors for gears, see:

Tolerances for Over-pin Measurement of Gears, May '57, p 194—Gives formulas and tables for converting AGMA specs for standard backlash and tooth errors to tolerances for over-pin measurements.

Avoiding Gear-tooth Interference, Nov '54, p 207—Simple method with design charts for calculating max diametral pitch that can be used without undercutting or nonstandard tooth forms.

Measurement and Control of Chatter in Gear Drives, Dec '56, p 168—Gives chatter analysis by instrument; equations, for computing speed variations and eccentricity; recommendations for gear reducers and drive motors.

—Frederick Marich

Nomographs give the answer . . .

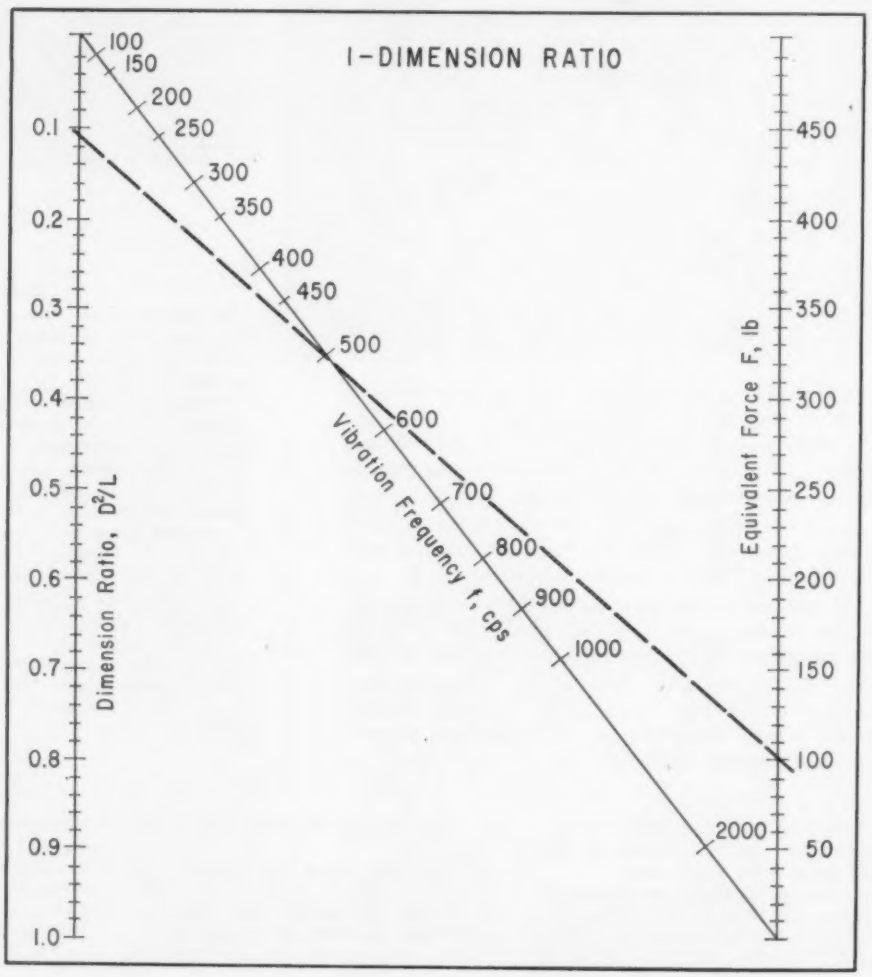
WHAT SIZE DRIVE ROD BETWEEN VIBRATOR AND TEST PIECE?

DOMENIC CERASUOLO, *dynamics test engineer*
Raytheon Co, Bedford, Mass

SYMBOLS

D = Diameter of rod, in.
E_a = Modulus of elasticity of metal other than steel, psi
E_s = Modulus of elasticity of steel, psi
f = Vibration frequency, cps
F = Equivalent force on rod, lb
g = Gravitational acceleration, in./sec²
L = Length of rod, in.
M_1 = Weight of vibrating part of mounting table, lb
M_2 = Weight of tested equipment, lb

In vibration-testing it is not always possible to attach the exciter directly to the piece of equipment being tested—often, therefore, a drive rod must transmit the vibrations to the test piece. For example, exciters cannot always stand the extremes of combined vibration and environment testing. Sometimes the magnetic field of the exciter coil affects electronic equipment being tested. And heavy equipment undergoing horizontal vibration-testing requires big exciters.



By supporting the equipment externally instead of on the exciter, a smaller exciter can be used, thus extending its load range. With a drive rod, the vibrator is outside the environmental chamber, its magnetic field at the electronic device is weak and it can vibrate heavier equipment.

EQUATIONS

Nomograph I solves for dimension ratio

$$D^2/L = 16F\pi f^2/Eg$$

Force $F = M_1M_2/(M_1 + M_2)$ includes only the weight of mounting table and equipment. Accuracy is 1 to 2%, good enough for low frequencies. At high frequencies, to get 1% accuracy, add in one-third of the rod's weight.

Value of modulus of elasticity E in the nomograph is for steel, 30×10^6. For a different metal, convert to the right diameter with the equation: true diameter $= D\ (E_s/E_o)^{\frac{1}{2}}$.

Nomograph II solves for diameter D after dimension ratio D^2/L has been found.

Example

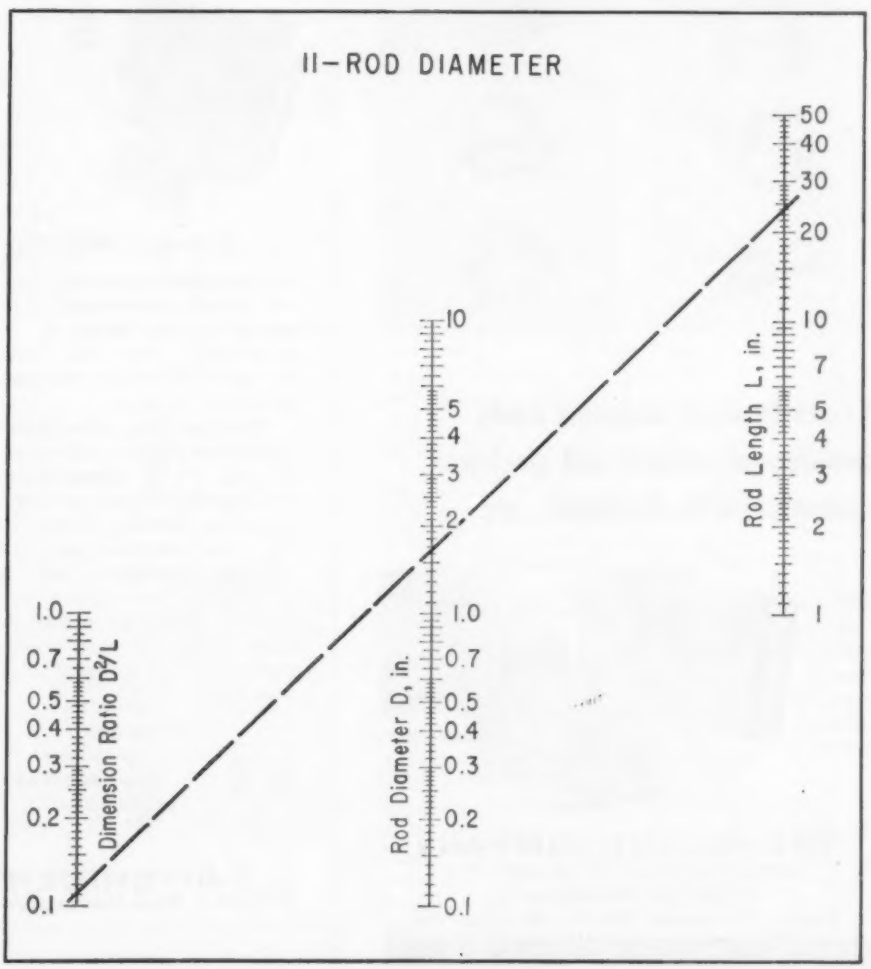
An exciter will be outside an environmental chamber, 24 in. from a 200-lb landing gear and 200-lb mounting table, which it will vibrate at 500 cps. What size should the drive rod be?

Solution

Equivalent force $F = M_1M_2/(M_1 + M_2) = 200 \times 200/(200 + 200) = 100$ lb.

Draw a line from $F = 100$ on the left scale of Nomograph I, through $f = 500$ on the slanting scale, to $D^2/L = 0.11$.

On Nomograph II draw a line from $D^2/L = 0.11$ at the left to $L = 24$ on the right. The line intersects the center scale at the answer, diameter $D = 1.63$ in. This is the minimum diameter.



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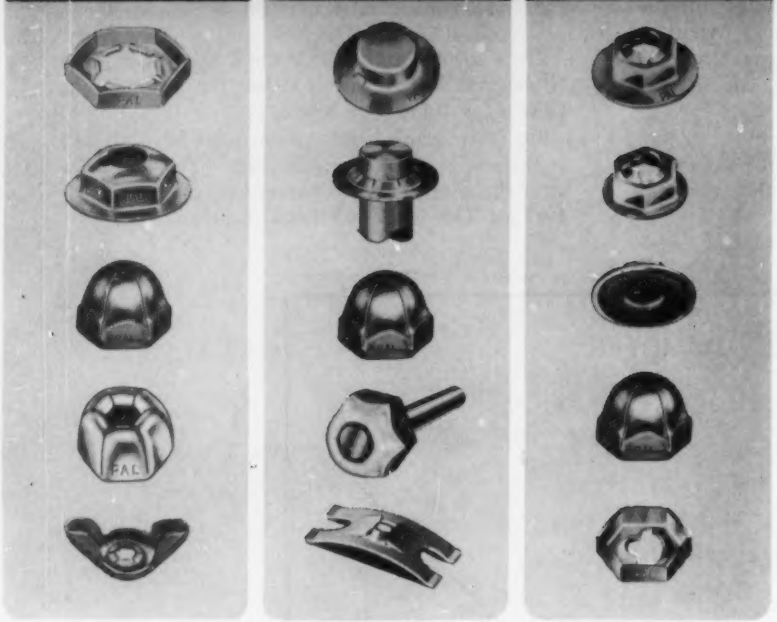

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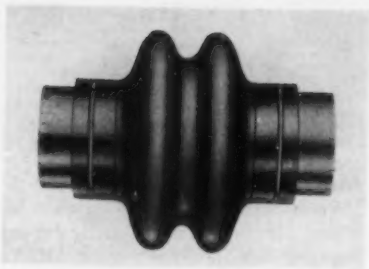
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Booted universal joints . . .

are suitable for heavy loads, high speeds and/or high heat. Useful where dust, dirt and other contaminants are problems, or any situation where lubrication with oil is difficult or impossible. Joints are fitted with oil-resistant neoprene covers which allow them to be prepacked with grease. Cover or boot, held in place by snap wires, does not affect joint performance, allowing operation through full 40° working angle. Standard duty joints are available from ⅜ to 2½-in. OD, with static torque range from 220 to 30,000 in.-lb, hp from 0.35 to 120 and speeds to 1500 rpm. Heavy-duty units have same OD, static torque range from 540 to 48,000 in.-lb, hp from 0.86 to 230 and speeds to 1750 rpm. Boot OD, depending on joint size, ranges from 1¼ to 5½ in. From stock. **Lovejoy Flexible Coupling Co, 4856 W Lake St, Chicago 44.**

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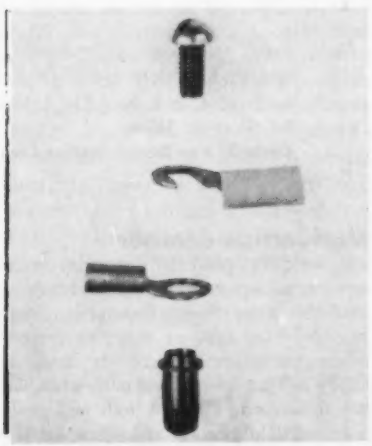

Insert makes electrical connection . . .

in molded plastic and is installed after molding, reducing open-press time and eliminating flash-removal operations. Electrical connection is formed by placing a terminal or contact strip over eyelet (protruding above workpiece surface) and then crimping eyelet over terminal. Lead wires are attached to connection by screw-threading conventional binding into insert. Four-eared brass spreader, prefitted inside tapered insert, anchors it into plastic. Spreader is pushed downward, expanding and locking insert's knurled external walls against the plastic. Size 6-32 insert provides min 18 in.-lb of torque and average of 240-lb pull-out strength. Available from stock in sizes 4-40 through 8-32 with 0.040 and 0.064-in. eyelet heights which will accommodate terminals with #6 through #10 holes in popular thicknesses. **Phelps Mfg Div, Heli-Coil Corp, Danbury, Conn.**

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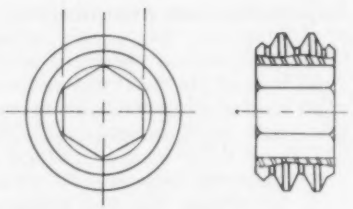

Socket jam screws . . .

have clear-through hexagon sockets, accessible from either end; high compression strength (alloy steel heat-treated to Rockwell hardness of C48-52); and short overall length (5/64 to ½ in.). Can be used for adjusting spring compressional forces in a detent application; as a forcing member when pin is used for locating or holding; or to lock another setscrew. From stock in No. 4- to 1-in. dia at $3.75 to $28.35 per 100. **Holo-Krome Screw Corp, Hartford 10, Conn.**

Circle 302 on Reader Service Card

Hard cellular elastomer compound . . .

is a solid, closed-cell molded compound which makes components such as carburetor floats leakproof even when holes are drilled completely through them. Material is billed as crushproof, chemically-resistant to all fuels and additives and unaffected by corrosion. **Rogers Corp, Rogers, Conn.**

Circle 303 on Reader Service Card

Pulse light source . . .

emits pulse of light 1 nanosec wide at 50% point when excited by an electrical pulse at a typical repetition rate of 100 pps. Size of light spot is a disk approx 0.010 in. in dia. A number of light sources can be excited any one time in an array—with time jitter between pulses less than 0.2 nanosec. Time delay can then be added with delay cables. Lights connect to 51-ohm coaxial cable. **PEK Labs Inc, 4024 Transport St, Palo Alto, Calif.**

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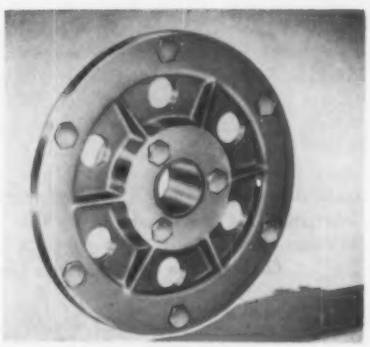

Sprocket hub . . .

is universally adaptable to all standard 4 5/16-in. ID sprockets. Hub is a precision casting using #380 aluminum alloy and is said to be 31% lighter than other hubs. Has recessed bolt heads, double tapered, noncreeping bushing and plated aircraft nuts and bolts. Priced at $4.95. **Azusa Engineering Inc, 16208 Arrow Hghwy, Azusa, Calif.**

Circle 305 on Reader Service Card

Subminiature solenoid . . .

from stock, is reported to be priced competively with 5 times larger, heavier unit having same performance characteristics. Measures 0.625 in. long x 0.438 in. dia

continued on page 86

and weighs 11 gm. Power input is 14 w; stroke, 0.125; and force, 260 g's. Allows continuous duty without burnout on 3 x 3 aluminum plate ¼-in. thick. Special construction is said to dissipate heat more readily from coil interior, allowing greater power input without threat of catastrophic failure. Unaffected by humidity, thermocycling, vibration, shock and acceleration. **Marshall Industries, 2065 Huntington Dr, San Marino, Calif.**

Circle 306 on Reader Service Card

Circulating ball slide . . .

for electronic rack and cabinet packaging, supports weights in 1000-lb range. Two circulating ball channels extend completely around top and bottom of slide, allowing easy sliding action. As chassis is pulled out of cabinet, weight is evenly distributed over all of bearing surface, and balls move in same direction as chassis. Available in standard sizes from 16 to 24 in. (in 2-in. increments) and from 24 to 60 in. (in 6-in. increments) on request. Slide, measuring 1⅛ in. wide and 3 in. high, is coated with a bonded film of molybdenum disulfide for permanent dry lubrication. **Chassis-Trak Inc, 525 S Webster, Indianapolis 19.**

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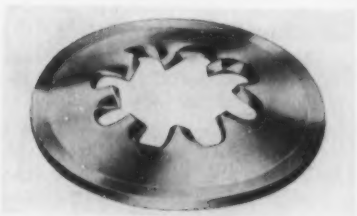

Flat-rim dish lock washer . . .

for fastening components to plastic and die-cast bodies, comes in sizes to fit small recesses or confined areas frequently found in electrical equipment. Rim is proportioned to support fastening load without injuring plastic by overstress or milling action. Conical body provides locking teeth with spring loading to protect unit from loosening due to vibration, cold flow of material or dimensional changes. Replaces split ring and flat washer for same applications. Available as free washer or as one-price, preassembled unit with either screw or nut. **Shakeproof Div, Illinois Tool Works, St Charles Rd, Elgin, Ill.**

Circle 308 on Reader Service Card

Glass-base epoxy . . .

is flame retardant and said to be easily fabricated. Laminate is available in 40 x 48-in. sheets with thicknesses ranging from $\frac{1}{32}$ to 1 in. In $\frac{1}{16}$-in. thickness, material can be sheared and punched with min heating. Flexural strength at that thickness is 66,000 psi lengthwise and 60,000 psi crosswise. Tensile strength is 52,000 psi lengthwise and 44,500 psi crosswise. **Spaulding Fibre Co Inc, 310 Wheeler St, Tonawanda, NY.**

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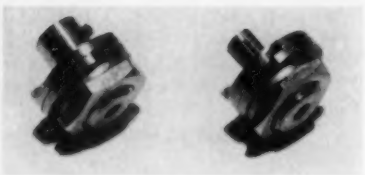

Adjustable cam assemblies . . .

in miniature size, have positive locking at any predetermined operational setting within range of 0 to 180°. Machined from #303 stainless steel with clear passivated finish, units are from stock in 0.1248-, 0.1873- and 0.2398-in. bore sizes and in pin- or clamp-type hub styles. **PIC Design Corp, 477 Atlantic Ave, East Rockaway, LI, NY.**

Circle 310 on Reader Service Card

Snap-in connectors . . .

maintain electrical properties at 500 F. Can be inserted and mated with 7-lb hand force and disconnected with handpull of 20 lb. Phosphor-bronze contacts in both male and female parts are interchangeable. Available in 13 sizes, ranging from 7 to 123 contacts. **US Components, 1320 Zerega Ave, New York 62.**

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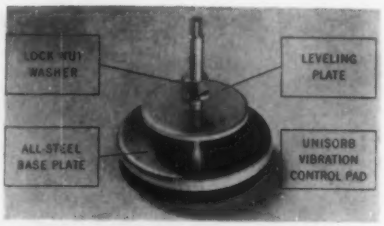
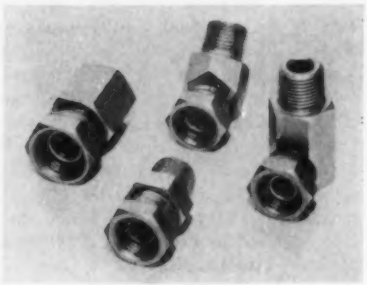


Machine mount . . .

levels equipment weighing as much as half a ton. Has sound- and vibration-dampening pad that prevents up to 85% of transmitted vibration from reaching floor and building structure. Available with either 3- or 4-in. leveling bolts and with any of three types of pad material for different load ranges. With mount, average machine tool reportedly can be positioned for less than $10. **Unisorb Div, Felters Co, 210 South St, Boston.**

Circle 312 on Reader Service Card



Pipe and hose fitting . . .

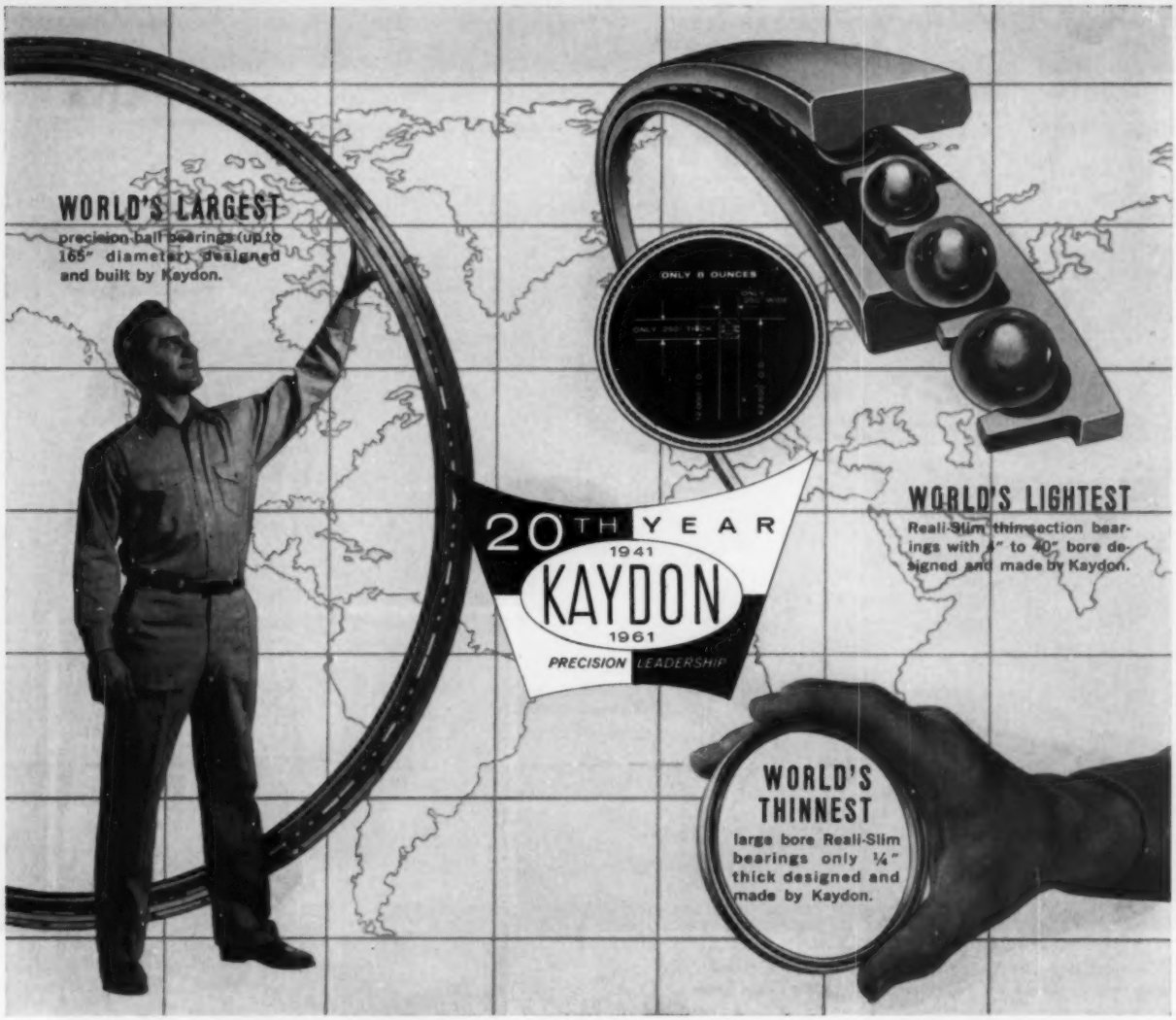
has swiveling nut which is turned to draw pipe or hose end against its chamfered seat, effecting a high-pressure seal. Made of brazed steel, fitting is available in four common straight and angle styles in pipe sizes up to 1 in. **L & L Mfg Co, 21590 Hoover Rd, Warren, Mich.**

Circle 313 on Reader Service Card

Malfunction detector . . .

automatically prevents repetitive cycle equipment such as injection-molding machines from closing improperly. Stops machine from applying clamping pressure when protruding objects (as small as 0.005 in.) are lodged in molds, when dies are misaligned, when tie rods and guideways need lubrication and when die pins tighten. Consists of visual control panel which permits monitoring of each die corner's proper closing, as well as any rise in hydraulic cylinder pressure; pressure

continued on page 89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Standard bearings often aren't adequate when you run up against a combination of limitations involving bearing capacity, size, weight, configuration, material and price.

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Kaydon builds your special bearings with close-tolerance precision, exceptional thrust or radial capacity . . . out of special metals or materials.

Don't penalize performance, or rule out new concepts in design, with stock bearings that "won't do." Call on Kaydon's long experience in design of special bearings that *will* solve your toughest problem.

Available! Reali-Slim type "CP" bearings off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new one-piece snapover bronze separator in 4" to 12" bore — ¼" to 1" width and cross section.

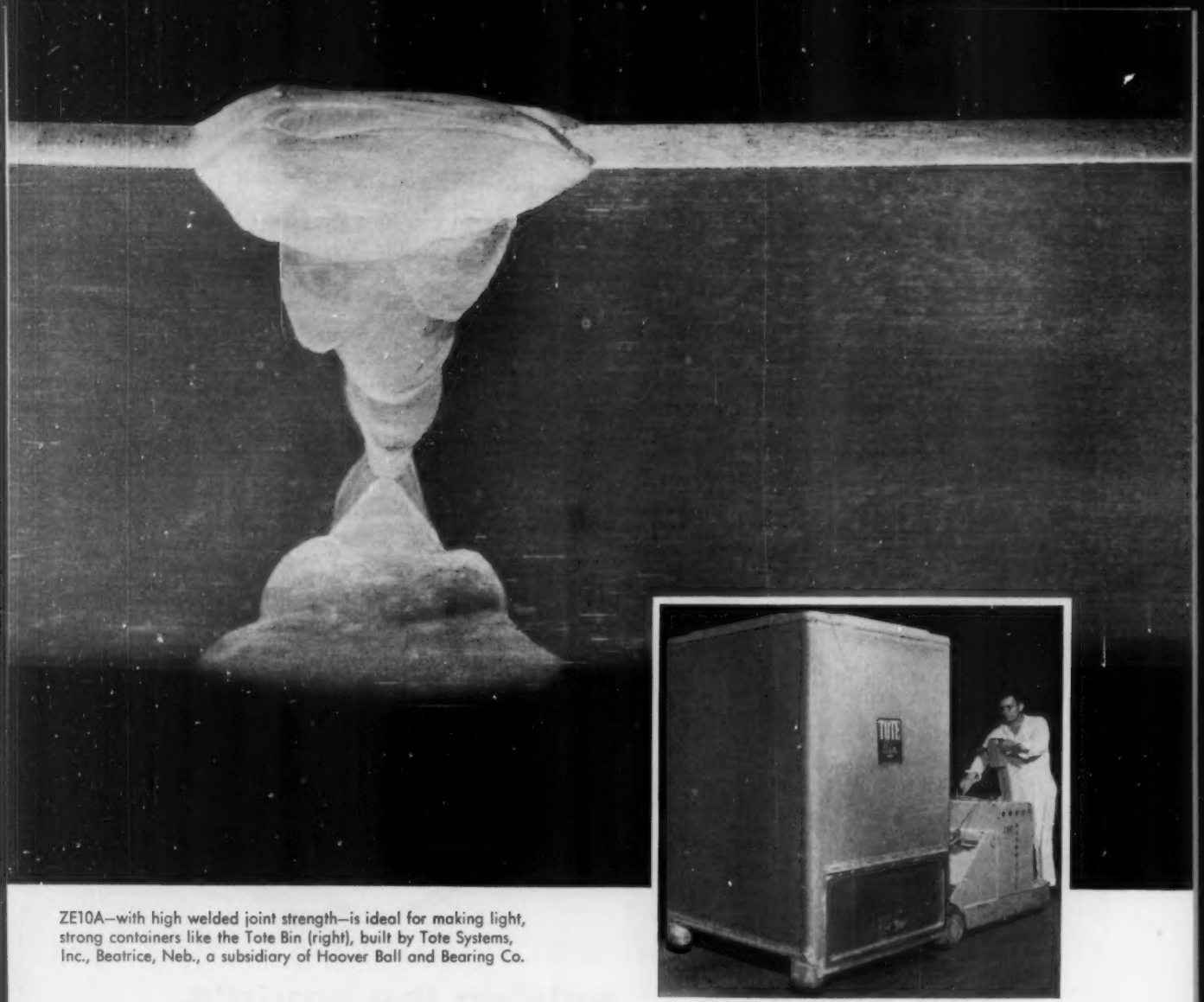
K-611

THE KAYDON ENGINEERING CORP.

•MUSKEGON, MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

World's highest capacity, lowest cost needle bearings (22 sizes available).



ZE10A—with high welded joint strength—is ideal for making light, strong containers like the Tote Bin (right), built by Tote Systems, Inc., Beatrice, Neb., a subsidiary of Hoover Ball and Bearing Co.

NEW DOW MAGNESIUM ALLOY ZE10A . . .

high welded joint strength and no stress relief!

New Dow magnesium alloy ZE10A needs no post-welding stress relief. This strong sheet alloy is tailor-made for fabricating containers, truck bodies and other large structures. And it's ideal for field repair operations where stress relief can be a real problem.

ZE10A also offers the advantage of very high welded joint strength, a matter of importance in butt welding. The result is strong, stiff, welded containers which are extremely light in weight . . . with greater capacity, pound-for-pound, than containers made from any other metal! And ZE10A provides maximum dent resistance.

When welding ZE10A magnesium sheet to extrusions, use Dow magnesium extrusion alloy ZK21A. *Neither* alloy requires stress relief after welding. For further information and data on Dow magnesium alloys, write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Department 1112DZ3-13.

DOW

THE DOW METAL PRODUCTS COMPANY

Division of The Dow Chemical Company

CIRCLE 88 ON READER SERVICE CARD

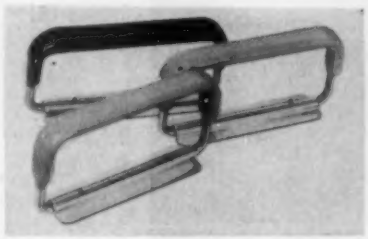
sensor fastened to die cylinder; and position sensors mounted on mold itself. Can be installed in existing equipment and uses no limit switches. Automatically compensates for temperature, mechanical and speed changes. Priced from $703.75. **Wintriss Controls, Div Industrionics Controls Inc, 20-24 Vandam St, New York 13.**

Circle 314 on Reader Service Card

Web control . . .

for fabric, paper or plastic film inspection, is a "go, no-go" gage that signals audibly or visually when width of a moving web falls outside preset tolerances. Can be installed on existing equipment, such as inspection perches, calenders, tenters, dryers or extruders. Wands sense each edge of web with feathertouch contact, and operator is alerted or process stopped when width fails to meet specification. Priced under $400. Delivery in 4 to 6 wk. **Matrix Controls Co Inc, Somerville, NJ.**

Circle 315 on Reader Service Card



Vinyl-grip aluminum handles

are available with tool to install keeper without handle. This allows equipment to be painted and baked before handle is attached. Supplied in grey or black with vinyl dip finish. Keeper comes with mounting holes for rivets or blank for spotwelding. **TA Mfg Corp, 4607 Alger St, Los Angeles 39.**

Circle 316 on Reader Service Card

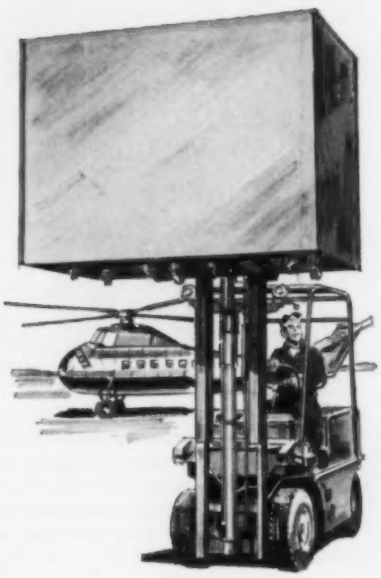
Photorelay system . . .

controls a counting device, motor, lighting, etc. by use of light beam interruptions. Consists of 2½ x 3½ x 4½ photorelay receiver and separate matching light source. Switches a 3-amp, 120-v resistive load at least two times a sec, with units up to 20 ft apart. Both units are plugged into standard outlet, and device to be switched is plugged into receiver's adapter plug. No current flows through device to be switched until light beam is broken and photocell is dark. Shifting a wire from one terminal to another allows operation when light is on the photocell. Receiver and

continued on page 90

DOW

HOW MAGNESIUM NO-RIB DESIGN CUTS CONTAINER COSTS AND WEIGHT



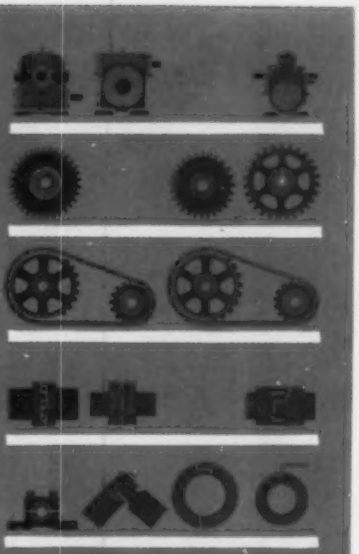
Cargo containers can be made both strong and light . . . and at less cost . . . with magnesium no-rib design. Fabricated from stiff sheets of lightweight magnesium, container walls need no stiffening ribs or supports.

No-rib design eliminates costly, time-consuming installation of ribs and fasteners . . . provides strong, dent-resistant walls that are smooth inside and out . . . produces economical containers that, pound-for-pound, have greater cubic capacity than ribbed containers of any other metal.

Dow magnesium sheet alloy ZE10A is ideal for no-rib construction. It provides high welded-joint strength and *needs no stress relief* after welding. For equipment handling and cargo containers, storage bins, vehicle bodies, magnesium no-rib construction offers maximum strength at lightest weight . . . and savings in construction time and costs!

DOW

THE DOW METAL PRODUCTS COMPANY
Division of The Dow Chemical Company
Midland, Michigan



INSTANT SOURCE

Charles Bond's large factory and distributor stocks provide an ideal "instant source" for Power Transmission Equipment for today's replacement and design applications. Frequently, the use of a Bond stock component eliminates the need to create a new component—with attendant delay and expense. When required Bond does create special units to your specifications.

Remember Bond—a leader in the power transmission field for three quarters of a century.

AGMA MEMBER

SEE YOUR NEAREST BOND DISTRIBUTOR

or check with Charles Bond Co. for: speed reducers—gears—flexible couplings — sprockets and chains—universal joints—collars —pillow blocks.

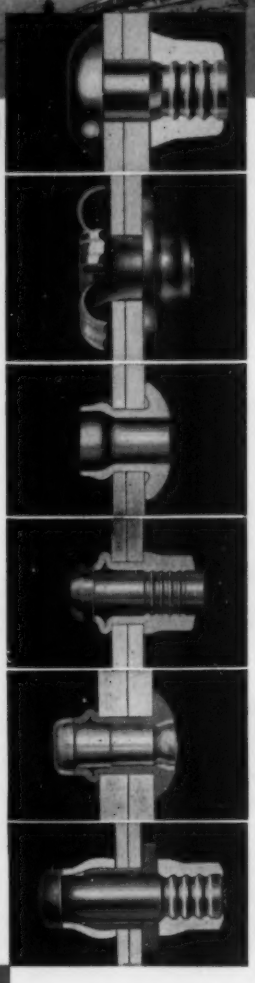
Write for Catalog No. 100

CHARLES BOND COMPANY

617-23 Arch Street, Phila. 6, Pa.

- GREATER STRENGTH
- UNIFORM TENSION
- MAXIMUM SHEAR STRENGTH
- PRECISION FIT
- LOWER INSTALLED COST

Huck permanent fasteners are available in many types, shapes and sizes, from ⅛" to ¾" diameter, to meet the requirements of all types of manufacturing, from railroad cars, trailers, buses, ships, blowers, appliances, to farm equipment and prefab buildings. These and many other users specify Huck fasteners for reasons of economy, speed of application, strength and dependability. You too, may find the answer to faster, better, cost-cutting assembly by investigating Huck's advantages. Write for literature, or ask for a Huck Sales Engineer who will be glad to explain the advantages of Huck Fasteners in your product. No obligation.



CL— Commercial Huckbolt

DR— Daisy Blind Rivet

PT— Pull-Thru Blind Rivet

OS— Oversize Structural Blind Rivet

MLS — Mechanical Lock Spindle Blind Rivet

BL— Blind Huckbolt

HUCK MANUFACTURING COMPANY

2480 Bellevue Avenue • Detroit 7, Michigan • Phone WA 3-4500

light source are available either together or separately. Sigma Instruments Inc, 170 Pearl St, South Braintree 85, Mass.

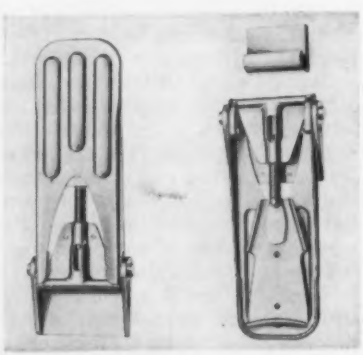
Circle 317 on Reader Service Card

Heavy-wall nylon tubing . . . for bushings, bearings, etc, is available in 10 sizes, starting with ¼-in. ID x 1-in. OD. Tolerances are: ID, +0.025, —0.00; OD, ±0.010. Nylon used is Type 6 or 66. Danielson Mfg Co, Danielson, Conn.

Circle 318 on Reader Service Card

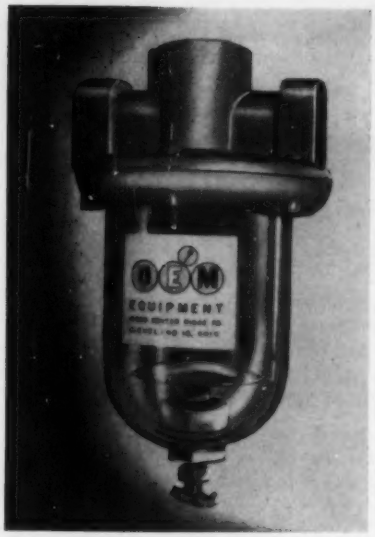
3- and 4-way air valves . . . have full ⅛-in. ports and ⅛ NPT air connects. Three-way valve is designed for single-acting air cylinder and 4-way unit for double-acting cylinder. Each measures 1 1⅜-in. high and has parts that can be replaced without removing valve from line. From stock. Bimba Mfg Co, 101 Main St, Monee, Ill.

Circle 319 on Reader Service Card



Drawhook latch . . . provides up to ½-in. adjustment with ultimate tensile strength of 1000 lb. Said to provide top load-deflection characteristics without springs. Common pivot of both drawhook and handle prevents accidental opening due to vibration and shock or buckling and misalignment of container sections. When latch is fully open, drawhook stows flat within handle. Camloc Fastener Corp, 62 Spring Valley Rd, Paramus, NJ.

Circle 320 on Reader Service Card



Manual-drain air filter . . . can be cleaned in the line without shutting off air or removing bowl. Screwdriver slot on filter element is aligned with pipe ports. When cleaning is required, element is turned 90°. This reverses airflow through element, and blows off accumulated dirt and moisture. Contaminants drop to bottom of bowl to be manually drained. There is said to be no perceptible pressure drop through high-strength monel screens. Unit, weighing 2 lb, 2 oz, is available in ¼-, ⅜-, and ½-in. full area pipe sizes. From stock at $12.75. **OEM Equipment, 19560 Center Ridge Rd, Cleveland 16.**

Circle 321 on Reader Service Card

High-flow relief valve . . . operating at pressures from 850 to 7200 psi, provides dead-tight sealing to well above 95% of preset cracking pressure. Increasing system pressure on poppet ups sealing efficiency. Said to have virtually no pressure rise with increasing flow, since system back pressure on poppet increases its lift and provides max flow characteristics. Operates at temperatures from —40 to 200 F and can be used as priority or sequence valve since unit is externally referenced. **Circle Seal Products Co Inc, 2181 E Foothill Blvd, Pasadena. Calif.**

Circle 322 on Reader Service Card

Solenoid-held lighted switch is 4PDT unit that combines functions of nameplate and pushbutton switch in one assembly. Consists of four double-turret terminal basic switches, a solenoid unit and standard lighted pushbutton. Has front-panel relamping, 6 or 28 v lamps, and takes up only 1 sq in. of panel space. Electrical rating is 5 amp at 125/250 v ac, 4 amp at 30 v dc resistive, or 2.5 amp

continued on page 93

14 WAYS TO
CUT DOWN-TIME!
fabric reinforced
VEE-DAM PACKINGS*
14 standard styles . . .
plus custom compounds
when necessary
• Suitable for use with a wide variety of liquids and gases on heavy-duty industrial equipment
• Positive control of annular leakage at the joint
• Eliminate need for solid rings
• Effective sealing over a wide temperature range
• Pressure is never a problem with a Linear Vee-Dam
* The Vee-Dam design is patented
SEND FOR special bulletin with detailed technical data on VEE-DAM PACKINGS. Linear, Inc., State Road and Levick St., Philadelphia 35, Pa.
"PERFECTION IN RUBBER"
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

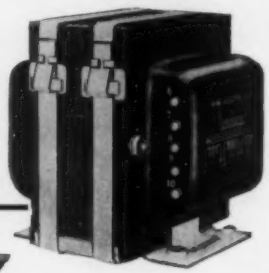
NEED ENCAPSULATED TRANSFORMER COMPONENTS?

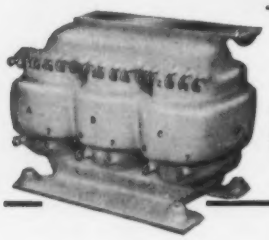
Do you need transformer components that must withstand high temperatures, low temperatures, excessive humidity or other environmental conditions and still perform in field service as well as under optimum laboratory conditions?

Then send your specs to Acme Electric and get the kind of cooperation you've always wished for — a complete study and analysis of your design, recommendations based upon the latest state of the art and suggestions for improvements and/or economies that will be of value to you.

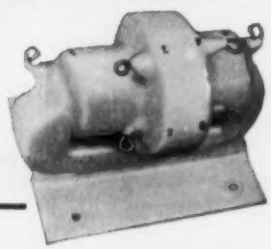
T-40902
Primary (1-2) 115 volts, 60 cycles
Secondary No. 1 (3-4-5)
71.5-0-71.5V RMS @ 77ma DC
F.W.C.T. Capacitor Input

MIL-T-27A
Grade 5
Class T
Life Expectancy X





T-34671
VA: 705, weight: 4¼ lbs.
165°C rise, 125°C ambient
12 KV test at 30,000 feet



T-36126
VA: 47.8, weight: 14 ounces
50°C rise, 250°C ambient
12 KV test at 30,000 feet

ACME ELECTRIC CORPORATION

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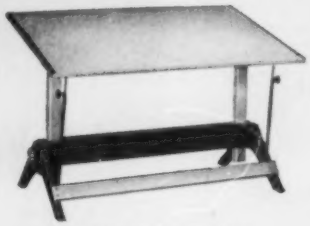
In Canada: Acme Electric Corp. Ltd., 50 Northline Rd., Toronto, Ont.

SAA 3420/1874

Acme ACME Electric
TRANSFORMERS

92 CIRCLE 92 ON READER SERVICE CARD

MAYLINE



V-MODEL PEDESTAL TABLE

Economical Drafting Tables Of Wood!

For efficient, sturdy, economical, long lasting wood drafting tables investigate Mayline products. Tables are both attractive and practical. They are sturdily built of Oak, with solid Basswood steel end cleat tops, which can be tilted thru an angle of 50 degrees.

Prices for the V-Model pedestal tables start at $65.55, and $98.25 for the 4-Post tables. Your local dealer can tell you more about these fine drafting tables.

MAYLINE COMPANY, INC.

607 NO. COMMERCE ST.

SHEBOYGAN, WISCONSIN

WOOD 4-POST TABLE

MAYLINE

MAYLINE

MAYLINE

CIRCLE 205 ON READER SERVICE CARD

NEW! 3-WAY PROTECTION for pressure instruments plant personnel

CHEMIQUIP'S COMPLETE SEALED SYSTEM PRESSURE SNUBBER

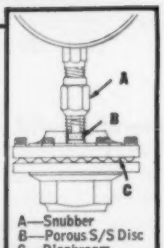
- Instrument and snubber will not corrode, plug or clog.
- Reduces fire hazard, noxious and toxic effects if instrument system ruptures.

Used with corrosive and/or viscous materials, Chemiquip's new combination also assures:

- Easy charging • Simple Solid filling, no spilling • Minimum calibration or adjustment.

And Chemiquip's snubber smooths line surges, pulsations—gives accurate readings in 2-3 seconds.

2 and 3 piece assemblies for systems to 2000 PSI.



A—Snubber
B—Porous S/S Disc
C—Diaphragm

CHEMIQUIP CO.

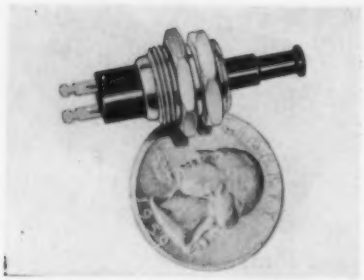
36 East 10th Street, New York 3
GRamercy 7-3772

Write, wire, phone NOW for new technical bulletin B55.

CIRCLE 206 ON READER SERVICE CARD

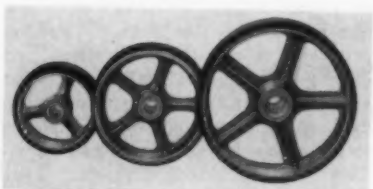
at 30 v dc inductive. Solenoid current is rated at 0.038 amp at 18 v dc or 0.060 amp at 30 v dc. Control Switch Div, Controls Company of America, 1420 Delmar Dr, Folcroft, Penna.

Circle 323 on Reader Service Card



Miniature push-pull switch . . . said to last for over 100,000 cycles, has "positive-feel" detent action with audible click. Can be maintained in either position until sufficient actuating force is applied in opposite direction. Measuring 1.492 in. long for ¼-in. mounting hole, switch is SPDT, normally open with butt contact. Rated at 1 amp, 115 v ac resistive with contact resistance of 0.010 ohm. Voltage breakdown rating—terminal to terminal and terminal to housing—is 1500 v ac. Priced at $1.15 each. Grayhill Inc, 561 Hillgrove Ave, LaGrange, Ill.

Circle 324 on Reader Service Card



Low-profile wheels . . . for manually operated industrial trucks, are said to have reduced flexing and deflection which cause ordinary tires to wear out prematurely when subjected to high load and torque. Rubber-tired, roller bearing wheels are available in sizes and compounds to meet most operating conditions. Divine Brothers Co, 200 Seward Ave, Utica 1, NY.

Circle 325 on Reader Service Card

Crimp-type contact connectors contain 34 to 104 closed-entry, beryllium copper contacts in miniature-rectangular, regular rack and panel, external, environmental and special designs. Contact sizes are #16 and #20, with crimp barrel to suit #16, 18, 20, 22 and 24 wire. In

continued on page 94

- Large Manufactured Head
- Oversize Blind Head
- Plugged or Hollow
- No Stem Trimming
- Minimum Blind-Side Clearance
- Excellent Head Seating
- Wide Grip Range
- Full Range of Diameters
- Positive Hole Fill
- Easy Installation

For fast, secure, more economical fastening, the new Cherry Commercial Rivet is a blind fastener ideal for production manufacturing and repair. Installed by one man from one side of the work, the Cherry Commercial Rivet reduces cost of assembly, repair and maintenance in both blind and open applications.

Minimum blind side clearance, adaptability to variations in material thickness, and positive hole fill even in oversize or out-of-round holes offer advantages not available in other production fasteners.

Cherry Commercial Rivets are available in both hollow (non-structural) and plugged (structural) types. The plugged rivets have strength values comparable to solid rivets, and stems fracture to eliminate all trimming operations and provide further production economy.

Grip lengths from 1/32" to 1" inclusive, and diameters of 1/8", 5/32", 3/16" and 1/4" are provided in either universal or countersunk head. Special rivets are manufactured to order.

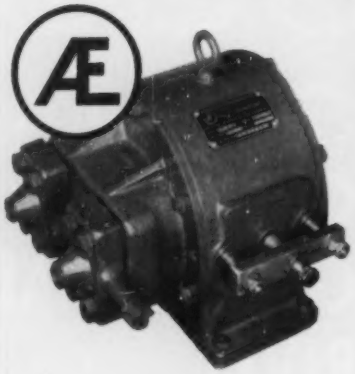
For full technical information on the new Cherry Commercial Rivet, write Cherry Rivet Division, Townsend Company, Box 2157-D, Santa Ana, California.

Aluminum Mild Steel Monel

CHERRY RIVET DIVISION
SANTA ANA, CALIFORNIA
Townsend Company
ESTABLISHED 1816 • BEAVER FALLS, PA.

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

IMPORTANT NEWS
FOR HYDRAULIC PUMP USERS



AMERICAN ENGINEERING'S HELE-SHAW and **HYDRAMITE** pumps are now being precision engineered and fabricated at the Aircraft Armaments, Inc. plant at Cockeysville, Md.

Be assured that the same craftsmanship and high standards of quality which make **HELE-SHAW** and **HYDRAMITE** pumps leaders in their field will be maintained in the **IMMEDIATE CONTINUED PRODUCTION** of these pumps by Aircraft Armaments, Inc.

Please address inquiries to:

AE INDUSTRIAL DIVISION
AIRCRAFT ARMAMENTS, INC.
Post Office Box 6853, Baltimore 4, Maryland

CLEVELAND DISTRICT: A. E. Company, 1157 Leader Bldg., Cleveland 14, Ohio

NEW YORK DISTRICT: A E Industrial Division, 1 Exchange Place, Jersey City 2, N. J.

CIRCLE 207 ON READER SERVICE CARD

"If you can't stand the heat —stay out of the kitchen"

MEYERCORD HEAT RESISTANT LINE OF DECAL TRANSFERS

H-R Heat Resistant	**S-H-R** Sustained Heat Resistant
H-R-T Heat Resistant Tubes	**H-H-R** High Heat Resistant

Ordinary Decals, when used as trademarks or operating instructions on products exposed to heat range of 150°F to 220°F will discolor, deteriorate and disappear.

Meyercord's exclusive H-R line of transfers—Heat-Resistant—will withstand operating temperatures up to 1,000°F. Four different types of H-R transfers are available for the job.

Write for Technical Bulletin No. 600. For Heat-Resistant markings specify Meyercord's H-R line.

Write today . . . on company letterhead, please

the MEYERCORD CO. Dept. C-318, 5323 W. Lake St., Chicago 44, Ill.

locked-in position, each contact resists 50 lb min push-out force even after several hundred cycles. **AirBorn Connectors Inc, PO Box 13251, Dallas 20, Tex.**

Circle 326 on Reader Service Card

Twin footswitch . . .

allows positive control of "up-down", "slow-fast", and other reversible operations with less foot pressure. Each of two footswitches, mounted on common steel base plate, provides momentary contact (press to start—release to stop) for SPDT circuits rated to 20 amp, 125/250 v ac and 1 hp, 115/230 v ac. Needs only one external power cable. Over-all size is $8\frac{3}{8}$ x $4\frac{1}{2}$ x $1\frac{1}{2}$ in. and weight without cordset, 4 lb, 13 oz. **Linemaster Switch Corp, 432 Woodstock Terrace, Woodstock, Conn.**

Circle 327 on Reader Service Card

Adjustable-speed drive . . .

with speed range from 2:1 to 100:1, operates from single-phase ac supply and has pair of grid-controlled thyratrons and diode tubes that provide full-wave rectified voltage to motor armature. Uses an IR drop compensating network for precise speed regulation regardless of load. Complete unit, comprising controller, push-button station and drive motor, is available in ratings from $\frac{1}{3}$ through 4 hp. **Square D Co, Dept SA, 4041 N Richards St, Milwaukee 12.**

Circle 328 on Reader Service Card

Hydrostatic transmission . . .

for mobile equipment, has cam-controlled variable-displacement pump driving either a fixed-displacement or variable-displacement hydraulic motor. With available

controls, speed of driven vehicle can be held constant under varying load or torque can be held constant at varying speed up to transmission's power limit. Specifications include: displacement, 4.5 cu in. max per rev for pump and motor; 28.5 gpm flow at 1500 rpm; 60-hp rating at 2000 rpm; 4500 psi max pressure at 0 to 4° cam angle, 2500 psi at 14° (3000 rpm); starting torque, 50 ft-lb per 1000 psi; and running torque, 56 ft-lb per 1000 psi. **New York Air Brake Co, Starbuck Ave, Watertown, NY.**

Circle 329 on Reader Service Card

Electric-start, aircooled engines . . .
rated 9.5 hp, includes 12-v combination starter-generator, battery-charging current regulator and control panel with ignition switch and starter button. Available with either magneto or coil ignition, engine is single-cylinder, four-cycle unit with cast iron construction and large bore, short stroke design. **Kohler Co, Kohler, Wis.**

Circle 330 on Reader Service Card

Spherical corner . . .
for weldments designed to eliminate square inside corners in rectangular containers, furnishes smooth tranistion from square to round and back to square again in any direction inside container. Prevents accumulation of sediment and subsequent corrosion at hard-to-reach points. Alsoacts as brace to protect container against damage of outer corners. Can be welded into existing tanks, and is available in three-in. size, furnished in two thicknesses of mild steel and grade 302 stainless steel. Priced from 66¢ to $1.95. **Conner Steel Products, PO Box 25, Southfield, Mich.**

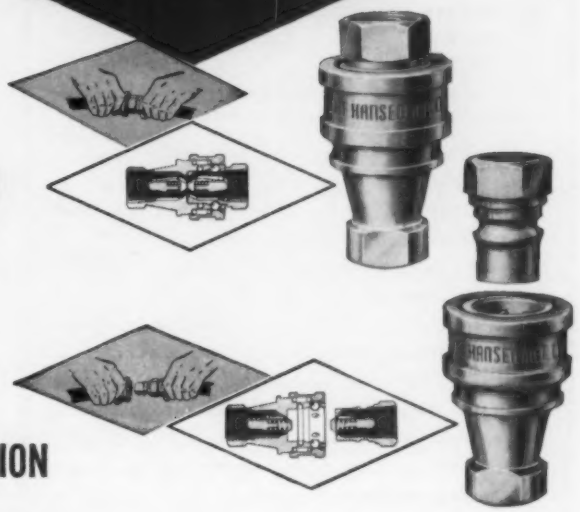
Circle 331 on Reader Service Card

Lettering is transferred . . .
off carrying sheet and onto any surface with just light pressure. No backing or carrying sheet is transferred—just letter itself. Font of letters in opaque black or white is processed on 10 x 15-in. plastic

continued on page 97

HANSEN

TWO-WAY SHUT-OFF COUPLINGS



QUICK CONNECTION

with instant automatic flow

QUICK DISCONNECTION

with instant automatic shut-off

...prevents loss of liquid, gas, or pressure

As easy as plugging in your electric shaver...

Write for the Hansen Catalog

Here is an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for LP-Gas, Steam, Oxygen, Acetylene, etc.

To connect a Hansen Two-Way Shut-Off Coupling, you merely pull back the sleeve and push the Plug into the Socket. To disconnect, just pull back the sleeve. No tools required. When Coupling is disconnected, similar valves in Socket and Plug shut off both ends of fluid line circuit—practically eliminating spilling of fluid at instant of disconnection.

Available in brass or steel, with female pipe thread connections from ⅛" to 1½" inclusive.

Representatives in Principal Cities ...see Yellow Pages

SINCE 1915 — QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 35, OHIO

FOR A QUOTATION ON AN

Environmental Chamber

TO MEET YOUR EXACT NEEDS, fill out and mail this data sheet

TO: WEBBER MANUFACTURING CO., INC.
P. O. Box 217
Indianapolis 6, Indiana

Please submit a quotation, without obligation to me, for an environmental chamber with the following specifications:

DESIGN: Top opening_____(or) Front opening_____

INSIDE DIMENSIONS: left to right_____

front to back_____top to bottom_____

TEMPERATURE RANGE DESIRED:

from +_____°F to minus_____°F

PULL DOWN TIME DESIRED

from +_____°F to −_____°F in_____minutes

CHAMBER WITH HEATING CYCLE: Yes_____No_____

Heat Up Time from ambient (+80°F) to +____°F in____minutes

FORCED AIR CIRCULATION INSIDE OF CHAMBER: Yes____No____

INSTRUMENTATION: Indicating_____

Recording_____Programming_____

POWER REQUIREMENTS:

_____volts_____phase_____cycle

INTERIOR LIGHT: Yes____No____ **CASTERS:** Yes____No____

VIEWING WINDOW: Yes____No____Size_____

TERMINAL PANEL: Yes____No____

Number of Terminals_____Size_____

PORTHOLES: Yes____No____

Quantity_____Size_____

CHAMBER WITH HUMIDITY CYCLE: Yes____No____

CHAMBER WITH ALTITUDE CYCLE: Yes____No____

to_____Feet

COMMENTS: _____

_____

Cut out and Mail

SEND YOUR QUOTATION TO:

NAME_____

MY NAME_____

COMPANY NAME_____

STREET ADDRESS_____

CITY_____ZONE____STATE_____

Have Your Representative Call Yes____No____

FREE BROCHURE!

This new 36-page brochure is the most helpful ever published for users of environmental chambers and low temperature freezers. It shows many of the types made by Webber—in any size, and with any temperature range.

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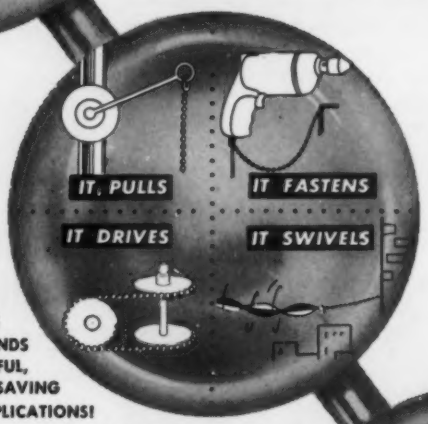

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PACKINGS to your specifications in leather, synthetics, asbestos, teflon, etc.

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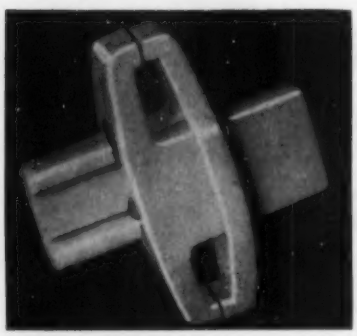
sheet, priced at $1.50 for most size letters. **Arthur Brown & Bros Inc, 2 W 46th St, New York 36.**

Circle 332 on Reader Service Card

Multipurpose electrometers

are useful as dc pre-amplifiers and have outputs for driving oscilloscopes and recorders. Line-operated model has 37 ranges from 0.1 to 100 v; battery-operated model, 31 ranges from 0.1 to 10 v, both accurate within 2% of full scale. Input impedance is over 10^{14} ohm with main selector dial on Volts. Former offers full scale current ranges of 10^{-11} to 10^{-4} amp, while latter covers from 10^{-13} to 10^{-6} amp. Both measures signals below one micro-microamp. Internal resistance measuring ranges are 10^{6} to 10^{12} ohm for the line-operated model; 10^{6} to 10^{11} ohm for battery-operated instrument. Former is priced at $390; latter, $280. **Keithley Instruments Inc, 12415 Euclid Ave, Cleveland 6.**

Circle 333 on Reader Service Card



Double-end clips . . .

for keeping notes, sketches, drawings together have spring action which allows them to open at either end with squeeze of fingers. Each measures 2 in. long and is made of plastic. From stock at $8.95 per 100. **Edmund Scientific Co, Barrington, NJ.**

Circle 334 on Reader Service Card

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Maxitorq

overload release clutches

Designers and builders have found MAXITORQ Overload Release Clutches the ideal way to provide dependable protection against overload conditions.

Unlike such devices as shear pins, the MAXITORQ Overload Release Clutch requires no disassembly or replacement after functioning. Once the cause of overload is removed or corrected, the machine may be re-started at once. Furthermore, MAXITORQ Overload Release Clutches may be adjusted for pre-determined overload protection.

In addition, users enjoy the proved advantages of the MAXITORQ Floating Disc Clutch . . . smooth, positive engagement and release . . . "floating" neutral with no drag or heating . . . easy manual adjustment.

We will be glad to give you the benefit of our long and successful experience in clutch and brake design; the overload release clutches are only one of many advanced MAXITORQ developments in both manual and electrically operated applications. Ask for literature, or outline your problem . . . write Dept. PE.

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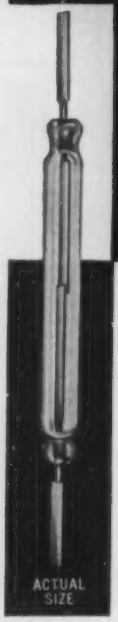
CLAREED

Sealed Contact Relays...

for contamination-free operation...positive on-off switching



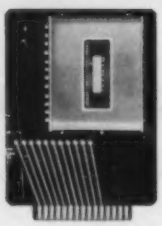
CLAREED solves the vexing problem of contact contamination. Its sealed, gold-plated contacts operate indefinitely in an in-built ideal environment, give positive on-off switching for up to millions of cycles. It is a relay you can install and forget.

This maintenance-free operation makes CLAREED sealed contact relays ideal components for such critical applications as transistor drives, computers, data processing equipment and many other high-speed devices.

CLAREED design is simplicity itself—a pair of magnetically operated contacts, hermetically sealed in an atmosphere of inert gas within a glass capsule. Compact size permits almost unheard-of flexibility of assembly and application.

Typical space-saving Clareed Relay Assemblies

Cylindrical can, containing CLAREED switch capsules which form core of common coil. Numerous variations to meet design needs.



CLAREED relay consists of 12 switch capsules enclosed in a rectangular container and mounted on printed circuit board.

CLAREED relay module for printed circuits. Quick mounting. High component density. Sturdy steel case provides magnetic shield.

If you use relays, it will pay you to know all about CLAREED relays...a new concept in relay design. To obtain Bulletin CPC-10, address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, 840 Caledonia Road, Toronto 19, Ontario. Cable Address: CLARELAY.

See Clareed Relays in working logic modules... No tubes, no transistors.

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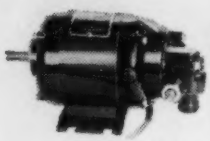
2T60 ELECTRONIC CONTROLLER with matching 1/50 H.P. DC MOTOR



$87 Complete, F.O.B., Las Vegas, Nevada

SPECIFICATIONS

● Thyraton tube operated controller gives stepless operation ● Input: 110-120 V., 60 cy. single phase ● Output: 0-120 V., 200 ma. DC to armature ● 1/50 H.P. ball bearing, right angle, gear head, shunt wound, DC motor ● Reversible ● Armature shaft is extended ● Armature speed 0 to 4000 R.P.M. ● Motors in gear ratios: 6, 18, 30, 36, 60, 100, 300, 540, and 1120:1 in stock.

Other models to 3/4 H.P. motors available. Request data.

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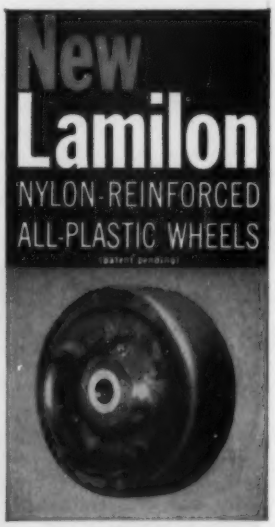

Now you standardize on one wheel for all your materials handling equipment. Fairbanks "Lamilon" Wheels protect your floors, for they stay smooth and concentric, don't mar or mark. Not affected by oils and greases, "Lamilon" Wheels have very high resistance to most chemicals, and have a water absorption factor almost as low as high quality rubber. With their alloy steel roller bearings, hardened steel outer race and provision for pressure lubrication, "Lamilon" Wheels roll easier, last longer and give more dependable service than any other plastic wheel.

Available in sizes 3 through 12 inches. Can be furnished with thread-tight thread guards.

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CIRCLE 98 ON READER SERVICE CARD

CIRCLE 211 ON READER SERVICE CARD

REPRINTS

Reprints currently available without charge are listed on the Reader Service Card bound in this issue. Single copy free; quantity prices on request.

The following special reports are available as long as the supply lasts, from Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36. Please enclose remittance; we pay postage.

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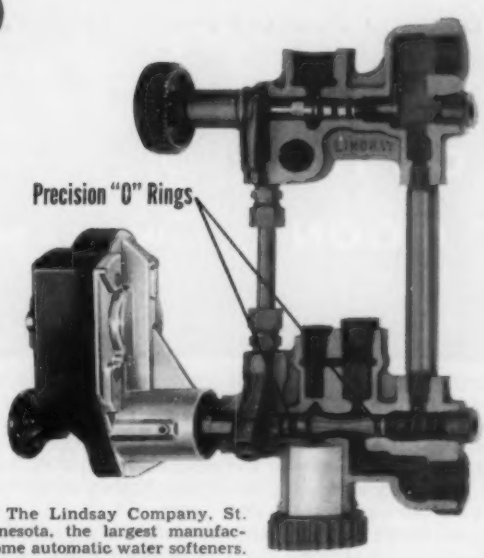

*Made for The Lindsay Company, St. Paul, Minnesota, the largest manufacturer of home automatic water softeners.

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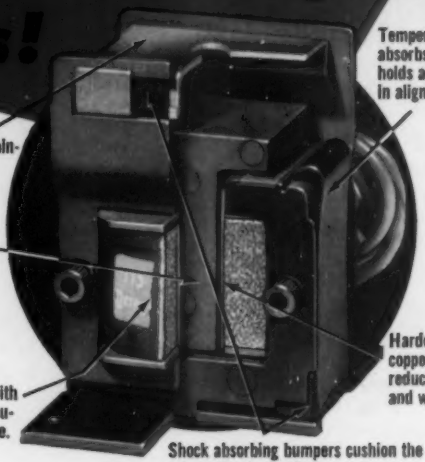
A model for your every need. Special solenoids may be engineered to suit special applications.


Tempered steel spring absorbs vibration, holds assembly firmly in alignment.
Striker plate of non-magnetic stainless steel.
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Hardened beryllium copper plunger guide reduces friction and wear.
High flow-point molded nylon bobbin, wound with heavy Nyclad insulated magnet wire.
Shock absorbing bumpers cushion the stroke, assure longer service.

Decco SOLENOIDS

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CIRCLE 212 ON READER SERVICE CARD

TO LAND ON THE MOON ...WITH A NOSE CONE OF CONOLON 506

The first U.S. space vehicle capable of making a "soft landing" on the moon, will start its journey in a 20-foot plastic shell—light, strong, and fabricated from Narmco's temperature-resistant CONOLON 506. The nose cone of the giant CENTAUR is an outstanding example of the adaptability of CONOLON 506 to applications which involve complicated assemblies such as the fabrication of the nose cone.

Narmco reinforced plastic laminating materials are produced in the form of rolls of fabric (such as asbestos, glass, nylon) impregnated with synthetic resins. Any number of layers can be used to build up structures of the desired strength and thickness. Epoxy, phenolic, polyester, and silicone laminate materials are available from Narmco as standard factory items. CONOLON 506 is woven glass fabric impregnated with modified phenolic resins, and is qualified to MIL-R-9299 Type I (general purpose) and Type II (heat-resistant), Class I (10 to 50 psi cure pressure).

In addition to the sophisticated fabrication of nose cones and missile parts, CONOLON 506 is also ideal for ducting, skin surfaces, fairings, molded accessories, metal close-outs, and many other applications. Under proper conditions, CONOLON 506 has a shelf life of six months, or more. This laminating material is also available in a variety of lengths and widths.

Goodyear-built RCA Radome, made of paper honeycomb core, and faced with CONOLON 525 skins.

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DESIGN LITERATURE

Science Since Babylon

DEREK DE SOLLA PRICE. Yale University Press, New Haven, Conn. 7 x 4½. $4.50.

As Professor of Yale University's History of Science Dept, Dr Price has written an elegant plea for a deeper understanding of the science historian as a possible bridge between the "two cultures" described by C. P. Snow (*PE*—Oct 10 '60, p 88). The history of science according to Dr Price is "the mid-region between the humanities and the sciences." He proposes a new undergraduate major composed of one part science, one part humanities, and one part history and philosophy of science. Science is part of the central core of our world, the author says. "Humanists of science at their research fronts might be able to diagnose the process, piece together parts of the mechanism of science, but only a public exposed in the colleges and schools to their findings about science can appreciate the depth and import of this cumulative activity that sets our culture apart from all that has come before."

The book is a compilation of five lectures delivered at Yale in the fall of 1959, and is certainly not intended to be a history of science. Rather it records a series of crises that Dr Price feels has affected the course of science, the birth of a "scientific civilization, the departure of science from the realm of pure thought, its transformation into scientific technology, and the transition of 19th-century classical theories to the explosive multiplication of our 20th-century discoveries. (See article extracted from this book in the Mar 6 issue, p 56.)—BAL

Polypropylene

O J KRESSER, Spencer Chemical Co, Orange, Tex. Reinhold Publishing Corp, 430 Park Ave, New York 22. 5¼ x 7¾, 268 pp. $6.50.

This book brings together all phases of polypropylene properties, production and applications. It offers information on this increasingly important thermoplastic at a level where it can be readily understood by readers without special training in polymer chemistry. Particular emphasis is placed on the relationship between the development of polypropylene and the future of high polymers in general. The book contains sufficient information on the basic principles of sterochemistry to point up the unique qualities of polypropylene.

Design of Worm and Spiral Gears

EARLE BUCKINGHAM and HENRY H RYFFEL. Industrial Press, 93 Worth St, New York 13. 6 x 9, 464 pp. $15.

The aim of the authors here has been to show how to obtain the benefits of improved design in spiral gears (crossed-axis helical gears) and worm drives through the use of all-recess-action design principles.

The book does two jobs: (1) It provides a step-by-step guide to the design of worm and spiral gear drives with all-recess action and (2) it presents certain basic principles with practices that enter into the successful design and manufacture of gears and gear drives of all types.

Cermets

A R TINKLEPAUGH and W B CRANDALL. Reinhold Publishing Corp, 430 Park Ave, NY. 9¼ x 6¼, 239 pp. $10.

This book is a thorough coverage of a narrow subject. It is the most complete assembly of information on cermets and includes the entire field, from fundamentals through process-

continued on page 102

introducing

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Nylatch, a new push-pull fastener, is now offered off the shelf to industry needing the ultimate in dependable low cost fastening.

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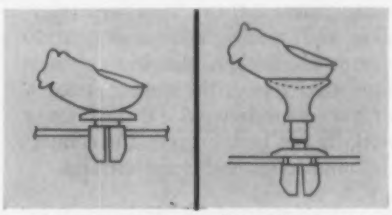
- Versatility of design allows you a selection of plunger head designs. Available in wide range of decorator colors.



Press grommet into removable sheet | Press plunger into installed grommet

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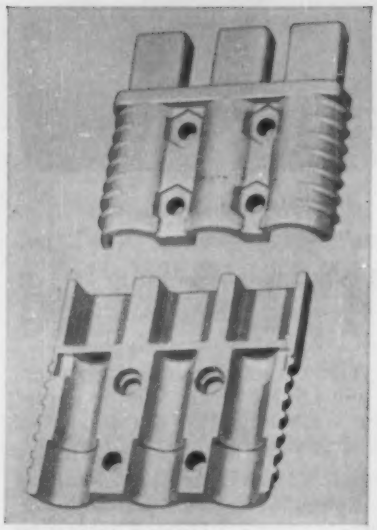
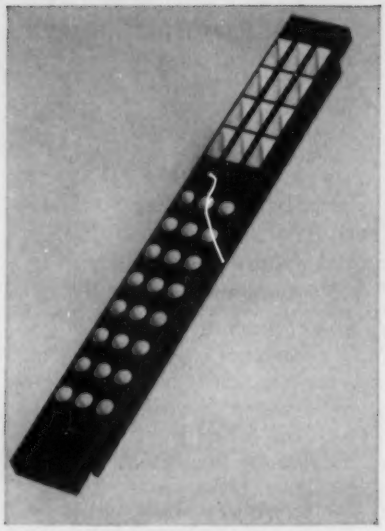
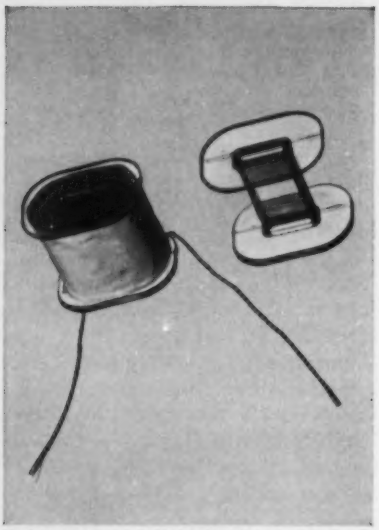
G-E LEXAN® POLYCAR



STRENGTH LEXAN resin has an impact strength of more than 12 foot-pounds per inch of notch — higher than any other plastic! This toughness, plus heat resistance and good electrical properties, make LEXAN resin an outstanding choice for 3-pole connectors used in rugged service on electric trucks.



HEAT STABILITY Lampholder terminal block is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. LEXAN has a heat distortion point as high as 290°F. Also keeps high strength in sub-zero cold.



ELECTRICAL PROPERTIES A good dielectric, LEXAN resin is non-corrosive even when used with very fine Class F magnet wire. Coil forms must not distort at temperatures above 200°F under stresses caused by tightly wound wire. LEXAN resin provides high heat distortion temperatures under load.

ing and practical applications. These materials—ceramic oxides or carbides modified with metal—extend the upper temperature limits of design because they have high creep and rupture strengths to 2500 F and beyond. The major drawback, low impact resistance, still remains. Even with cladding and special fastener designs to eliminate notches, the best cermets have only $\frac{1}{2}$ to $\frac{1}{10}$ the impact strength of the poorest metal. If this major obstacle can be overcome, the cermets will find much wider applications.

Formulas for Stress and Strain

RAYMOND J ROARK. McGraw-Hill Publishing Co, 330 W 42nd St, New York 36. 9¼ x 6 in. 381 pp. $8.25.

Some of the additional information in this third edition includes more data and formulas on shear lag, circular arches, flat plates, pressure vessels, stress concentration factors.

The book is intended primarily as a reference book and makes available a compact summary of formulas, facts and principles pertaining to strength of materials. It is divided into three parts: In Part I are defined all terms whose exact meaning might otherwise not be clear. In Part II certain useful general principles are stated; analytical and experimental methods of stress analysis are briefly described, and information concerning the behavior of material under stress is given. In Part III the behavior of structural elements under various conditions of loading is discussed, and extensive tables of formulas for the calculation of stress, strain, and strength are given.

Derivations of formulas and detailed explanations, such as are appropriate in a text book, are omitted, but a sufficient number of examples are included to illustrate the application of the various formulas and methods.

Other Books of Interest

Materials Testing Bibliography (1950-1960)

Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10½, 16 pp. 10¢.

Glossary of Terms for Fluid Power

National Fluid Power Assn, 5595 N Hollywood Ave, Milwaukee 17. 8½ x 11, 31 pp. $1.

For the Years to Come

J F Thompson, N Beasley. G P Putnam's Sons, 210 Madison Ave, NYC. 5¾ x 8½, 374 pp. $5.

The development of the nickel-mining and refining industry in Canada.

Columbium and Tantalum Bibliography

Office of Technical Services, US Dept of Commerce, Washington 25, DC, 8 x 10½, 14 pp. 10¢.

Lists reports in OTS' monthly abstract journals, 1945-1958.

Molybdenum and Tungsten Bibliography

Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10½, 18 pp. 10¢.

Lists reports in OTS' monthly abstract journals, 1944-1959.

Beryllium Bibliography (1945-1960)

Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10½, 19 pp. 10¢.

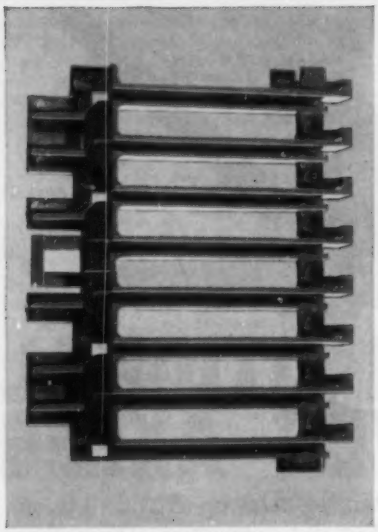
Lists reports in OTS' monthly abstract journals, 1945-1960.

The Structure of Glass, Vol 2

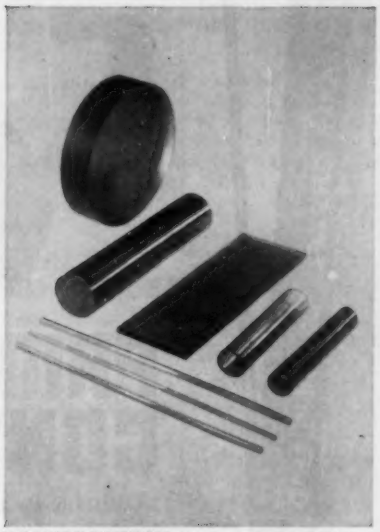
Translated from Russian. Consultants Bureau Enterprises Inc, 227 W 17th St, NY 11. 8½ x 11, 480 pp. $25.

The first technological book ever to be published simultaneously in the English-speaking and Russian-speaking worlds. Contains proceedings of Nov '59 Conference on the Glassy State held in Leningrad.

BONATE RESIN TOUGHEST OF PLASTICS!



DIMENSIONAL STABILITY Card Guide for business machines is molded to close tolerances . . . must undergo minimum change in dimensions during service. Parts show excellent dimensional stability under moist and high temperature conditions. LEXAN resin meets self-extinguishing requirement.



TRANSPARENCY Stock shapes and film of LEXAN polycarbonate resin have excellent transparency. Bar stock is easily machined; film can be thermoformed, heat-sealed and solvent-sealed. Combination of clarity, toughness and malleability gives LEXAN resin the design capabilities of a transparent metal!

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Bearings Bibliography (1945-1960)
Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10½, 17 pp. 10¢.
Lists reports in OTS' monthly abstract journals, 1945-1960.

Metal Coatings Bibliography (1950-1960)
Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10½, 20 pp. 10¢.
Lists reports in OTS' monthly abstract journals, 1950-1960.

ABSTRACTS FROM THE LITERATURE

Valve-flapper Force

This paper describes some experiments that were made to determine the force on the flapper of a flapper valve.

The force on the flapper is determined by adjusting the upstream pressure until, for a given set of balance weights, the force transducer records a set value. The net force on the flapper is then the sum of the balance weights and the force exerted by the transducer.

The distance between the flapper and the nozzle was determined optically. The flapper was highly polished so that by looking in from the side one could see both the nozzle and its reflection in the flapper. Observing at an angle very close to the horizontal shows twice the actual distance of separation between the nozzle and the flapper.

"The Force on the Flapper of a Pneumatic Flapper Valve," R. E. Norwood, MIT, Cambridge, Mass. Paper No 38.4 published in NEREM Record, Nov '60, Institute of Radio Engineers, (Boston section), Boston.

U-springs

Charted parameter makes possible a simplified method of finding stress and deflection. Advantages of the U-spring in comparison with other springs are shown.

"U-springs—Stress and Deflection Calculations," by J. E. Fleckenstein, Johnson Service Co. American Society of Mechanical Engineers paper 60-WA-172, 29 W 39th St, New York 18.

States of Polymers

The different states of polymers have been determined by thermal, mechanical, and electrical methods to follow the change of characteristics as a function of temperature.

Diagrams give the breaking or the yield stress of some materials as a function of temperature, and also their transition temperatures. These diagrams, which collect the results of experiments, seem to be fundamental for the various thermomechanical applications.

The possibility of the three states, namely, rigid, plastoelastic, and rubbery, is examined with respect to the basic structure of the polymers. As

continued on page 105

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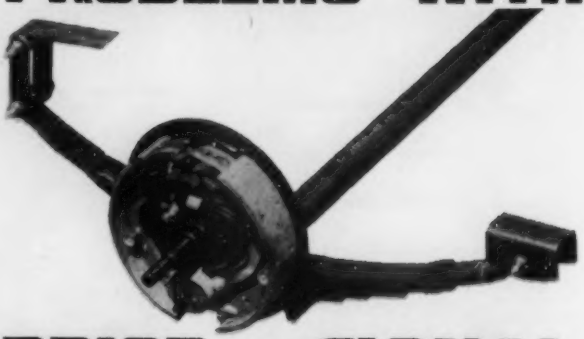

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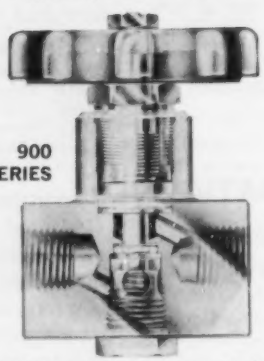

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polymers are viscoelastic solids, special attention has been given to the change of characteristics as a function of time.

"The Different States of Polymers Based on Their Thermomechanical Properties," by M. Chatain, P. Dubois, Centre d'Etude des Matieres Plastiques, 21, rue Pinsel, Paris 13°. Presented at the 17th Annual Technical Conference, SPE, 65 Prospect St, Stamford, Conn.

Lubricating Frictionless Bearings

Theoretical analysis, photoelastic tests and ball-bearing fatigue tests led to an hypothesis explaining the influence of oil on bearing fatigue life. The conclusion is that oils which produce lower thermal gradients in the contact zone help to give longer life.

"Theory of Lubrication and Failure of Rolling Contacts," by B. Sternlicht, P. Lewis and P. Flynn, General Electric Co. American Society of Mechanical Engineers paper 60-WA-286, 29 W 39th St, New York 18.

Finishes on Laminate Systems

The subject of this paper is the investigation of finishes on glass fabric reinforcement and their effect on the properties of heat-resistant phenolic and epoxy systems, particularly on laminates that have been post-cured to high temperature. The findings substantiate that the finish is paramount especially in the phenolic system; this was not so pronounced in the epoxy laminate systems. Results of the physical properties and electrical properties are tabulated on the post-cured laminates and the most important features are pointed out in the form of bar graphs.

"The Effect of Finishes on Heat Resistant Phenolic and Modified Epoxy Laminate Systems," by John Miglarese, Westinghouse Electric Corp. Presented at the 17th Annual Technical Conference, SPE, 65 Prospect St, Stamford, Conn.

Molded Brake Lining

Test results show coefficient of friction for three representative materials under various conditions. A main conclusion is that a deposited microscopic intersurface increases the coefficient of friction.

"The Dynamic Frictional Characteristics of Molded Friction Materials," by M. J. Rabins, New York University and R. J. Harker, University of Wisconsin. American Society of Mechanical Engineers paper 60-WA-35, 29 W 39th St, New York 18.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

METALLIC STATIC-FACE SEALS—Booklet, approx 26 pp. Outlines characteristics, dimensions, and requirements and precautions for handling and installing. Includes dimensional drawings and installation diagrams. Harrison Mfg Co, 2908 N Naomi St, Burbank, Calif.

Circle 350 on Reader Service Card

POWER POSITIONERS—Bulletin 500A, 10 pp. Discusses basic uses, operation and dimensions. Visual flow illustrations, line drawings and charts show ways of applying positioners to air-hydraulic power cylinders, motorized screw drives and other regulating devices. Hanna Engineering Works, Dept PR-27, 1765 Elston Ave, Chicago 22.

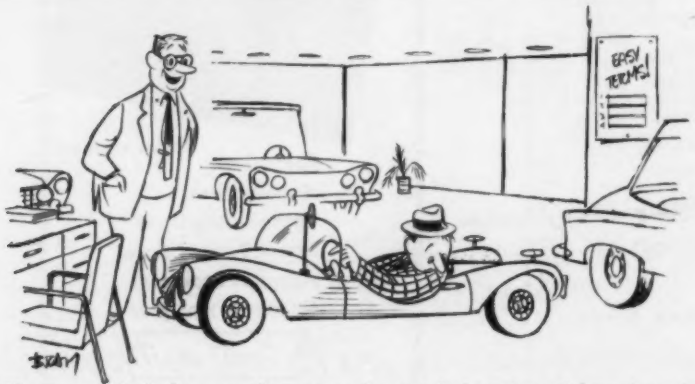
Circle 351 on Reader Service Card

HYDRAULIC FLUIDS, LUBRICATING OILS – Catalog, 6 pp. Carries references on over 450 military specifications for lubrication, hydraulic, and corrosion prevention products. Bray Oil Co, 3344 Medford St, Los Angeles 63.

Circle 352 on Reader Service Card

FRICTION MATERIALS – Brochure 1051, 4 pp. Tabulates tensile strength, coefficient of friction and recommended

continued on page 107



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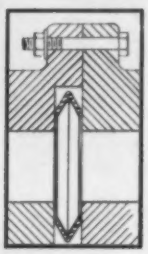

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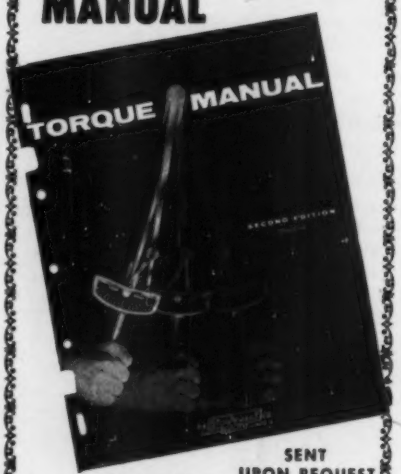

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FLOATLESS LIQUID-LEVEL CONTROLS—Bulletin 334, 4 pp. Describes performance of high- and low-sensitivity types; offers specifications and direct and inverse operation diagrams. B/W Controller Corp, 2200 E Maple Rd, Birmingham, Mich.

Circle 354 on Reader Service Card

RIGHT-ANGLE PRINTED CIRCUIT CONNECTORS—Catalog RTA-1260, 12 pp. Contains electrical and mechanical ratings, outline drawings and photographs of plug and socket connectors in contact sizes from 4 to 38. Electronics Div, DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.

Circle 355 on Reader Service Card

ADJUSTABLE-SPPED DRIVES—Bulletin 2900, 6 pp. Describes operation of four types of packaged drives for applications in the ¾ to 2500-hp drive range and gives available ratings, speed ranges, type enclosures, etc. Cutaway drawings are included for each. Louis Allis Co, 427 E Stewart St, Milwaukee 1.

Circle 356 on Reader Service Card

ADJUSTMENT POTENTIOMETERS—Folder 4700, 4 pp. Tabulates resistances, end settings, power ratings, max operating temperatures, terminals, etc. of 18 models. Typical design features are shown in cutaway drawings of four models. Schweber Electronics, 60 Herricks Rd, Mineola, LI, NY.

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SHADED-POLE AND GEARMOTORS—Brochure, 4 pp. Presents size, speed and torque data on shaded-pole induction motors and helical, spur and worm gearmotors. Dimensional drawings are included for each series. Brevel Products Corp, 601 W 26th St, New York 1.

Circle 358 on Reader Service Card

FITTINGS—Bulletin 921, 17 pp. Contains outline drawings and specifications of adapter couplings, bushings, elbows, tees, hose assemblies and brackets. Diagrams relationships of different pipe thread types and outlines pipe thread dimensions and characteristics as well as standard gaging practices. Lincoln Engineering Co, Original Equipment Sales Div, 4010 Goodfellow Blvd, St Louis 20.

Circle 359 on Reader Service Card

MOLDED ELECTRIC-MOTOR PARTS—Catalog, 12 pp. Illustrates and lists stock sizes of molded brush-retaining caps, carbon brush holders, commutators and slip rings. Midwest Molding & Mfg Co, Gurnee, Ill.

Circle 360 on Reader Service Card

HIGH-IMPACT MOLDABLE PLASTICS—Booklet, 28 pp. Covers physical and chemical properties of acrylonitrile-butadiene-styrene thermoplastic resins for engineered applications. Also gives design information on many molded products made from the material. Kralastic Sales Dept, Naugatuck Chemical Div, US Rubber Co, Naugatuck, Conn.

Circle 361 on Reader Service Card

WELDING STAINLESS STEEL—Bulletin 7300.2, 12 pp. Traces physical properties, structure and welding characteristics of different types of stainless steels. Also tabulates deposit properties and electrode recommendations. Lincoln Electric Co, Cleveland 17.

Circle 362 on Reader Service Card

STRUCTURAL TUBING—Bulletin 12-3, 4 pp. Provides size data on square, rectangular and round steel tubing; lists advantages of structural tubing over other steel shapes; and discusses tolerances and fabrication. Joseph T Ryerson & Son Inc, Box 8000-A, Chicago 80.

Circle 363 on Reader Service Card

NUMERICAL CONTROL OF MACHINE TOOLS—Booklet 24 pp. Explains fundamentals of operating machines with electrical motors that get their

continued on page 109

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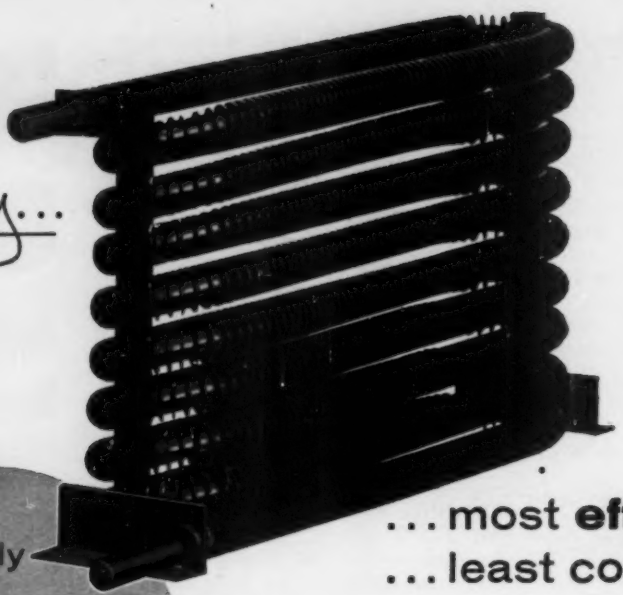

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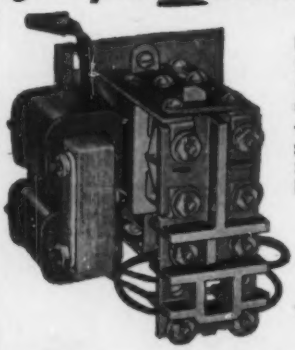

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PUSHBUTTON STATIONS—Bulletin GEA-6544A, 8 pp. Describes line for standard and heavy-duty applications and includes dimensional diagrams. Ordering information spells out number and type of operators, nameplate markings, wiring symbols, etc. General Electric Co, Schenectady 5.

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THERMOPLASTIC MATERIALS—Chart. Offers physical, electrical, chemical and optical properties of acrylics, acetate, butyrate, Teflon and Kel-F fluorocarbons, nylon, polyethylene and vinyls. Cadillac Plastic & Chemical Co, 15111 2nd Ave, Detroit 3.

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WIRE CONTACT RELAYS—Bulletin 2 pp. Contains specifications data, including coils, dielectric strength and contact ratings, on 4-, 6- and 12-pole plug-in units. Wheelock Signals Inc, 273 Branchport Ave, Long Branch, NJ.

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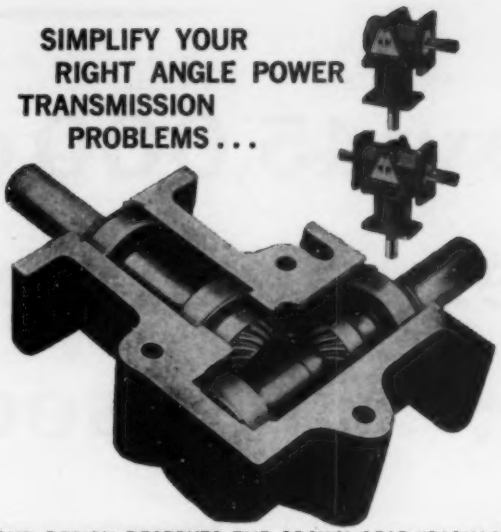

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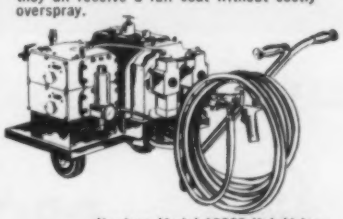

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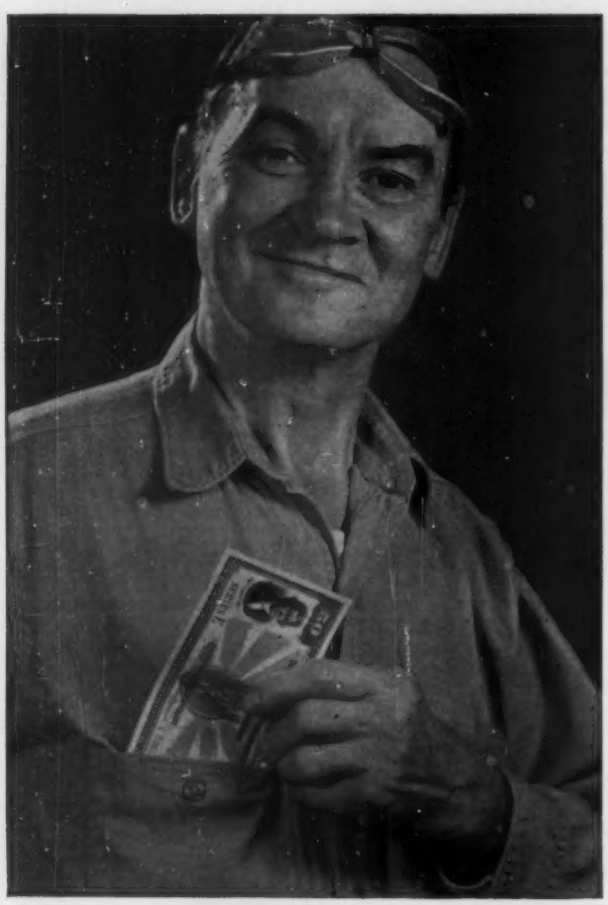

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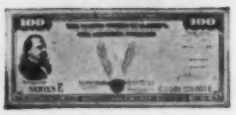

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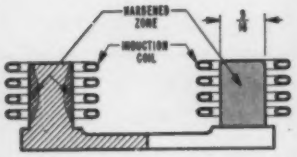

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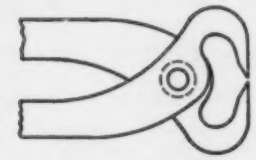

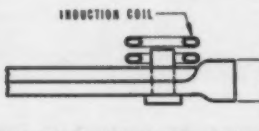

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20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P69 P70 P71 P72 P73 P75 P76 P77 P78 P79 580 581
582 583 584 585 586 587 588 589 590 591 592 593

*MULTIPLE PRODUCT ADS	
Key No.	Specific Product

(please print or type) *If this is change of address, check box* ☐

Name.....Title.....
Street.....
City.....Zone.....State.....
Company.....Major Product Manufactured.....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
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17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

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*MULTIPLE PRODUCT ADS	
Key No.	Specific Product

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Issue of March 13, 1961
PRODUCT ENGINEERING
Card expires May 12, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

Inquiries Services Department
PRODUCT ENGINEERING
P.O. Box 601
Ridgefield, Connecticut

22 FL

Issue of March 13, 1961
PRODUCT ENGINEERING
Card expires May 12, 1961

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PERMIT No. 64
NEW YORK, N. Y.

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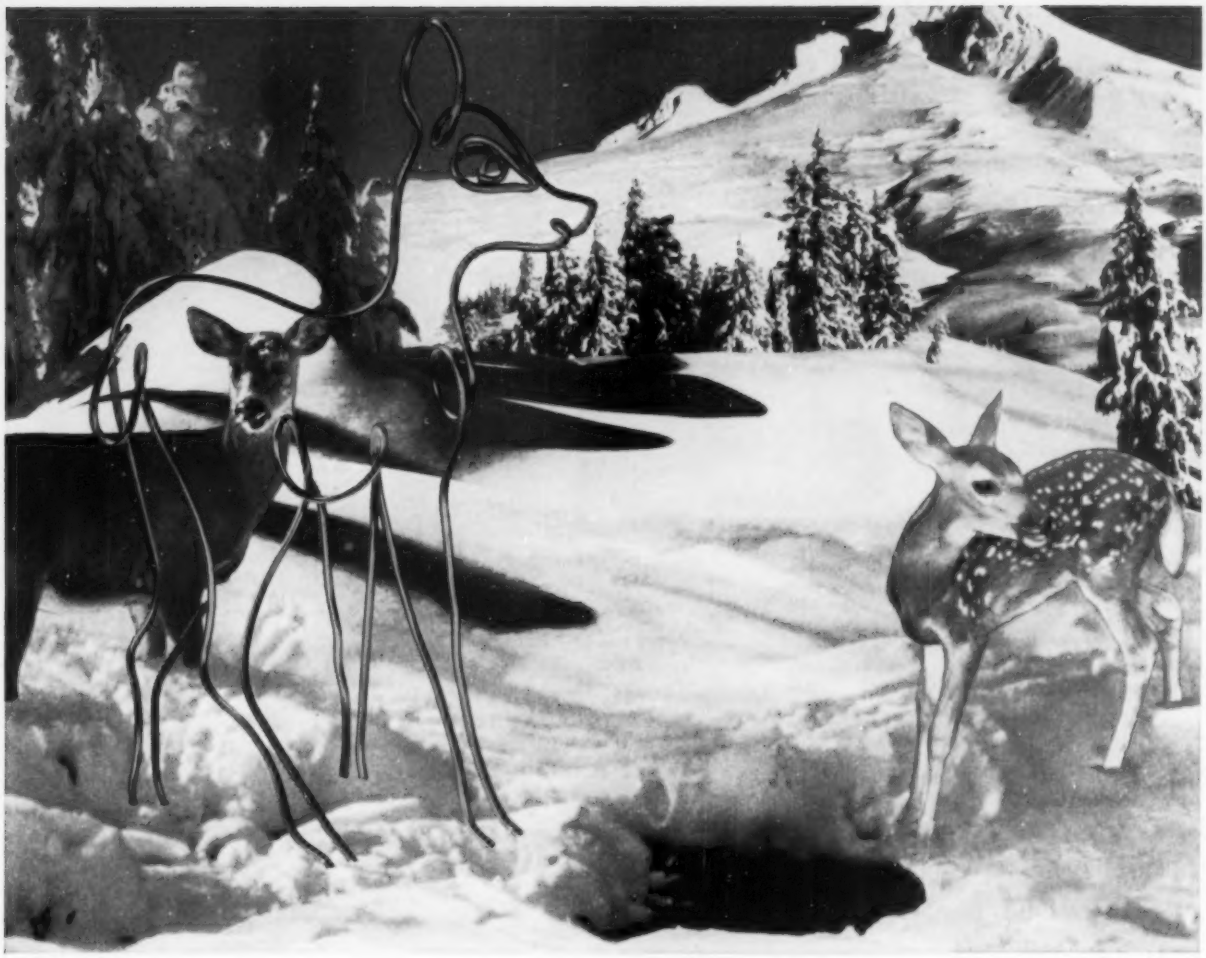
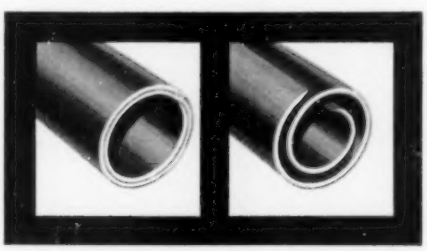


Bundy can mass-fabricate practically anything

Your most complex tubing designs are turned into tight tolerance components at Bundy. It's done with Bundyweld®, the tubing for design engineers with special problems. In addition to cutting, burring, flaring and bending, Bundy can expand, swage, flatten, upset, coil, bifurcate or machine this tubing to your specifications. In fact, Bundy can mass-fabricate practically anything. And Bundyweld meets ASTM 254; Govt. Spec. MIL-T-3520, Type III. Our engineers will work with you at any time. Just call, write or wire: Bundy Tubing Company, Detroit 14, Mich.

* * *



Bundyweld, double-walled from a single copper-plated steel strip, is metallurgically bonded through 360° of wall contact. It is lightweight, uniformly smooth and easily fabricated . . . has remarkably high bursting and fatigue strengths. Sizes up to 5/8" O.D.

BUNDY® TUBING COMPANY

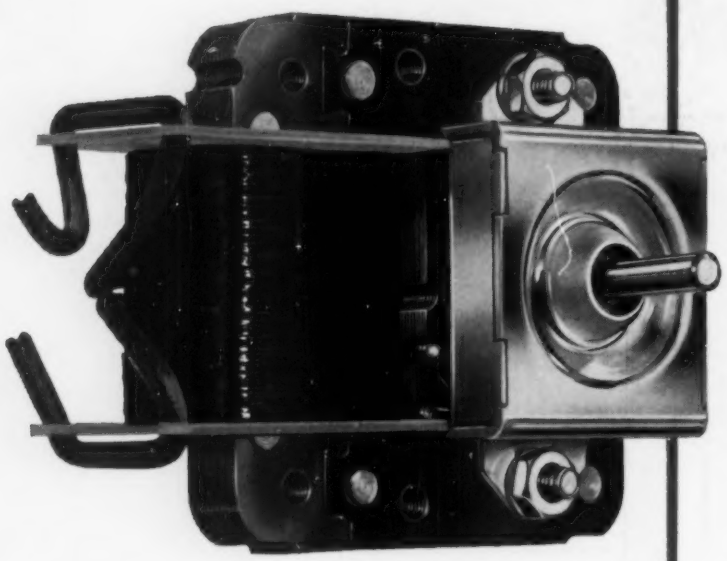
DETROIT 14, MICH. • WINCHESTER, KY. • HOMETOWN, PA.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, ITALY, JAPAN.

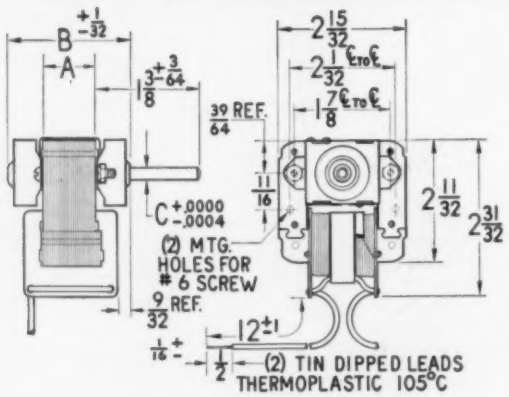
CIRCLE 202 ON READER SERVICE CARD

NEW TYPE EA1 UNIVERSAL SKELETON MOTOR

a superior unit because of quality construction, larger bearings and greater oil capacity



- Larger bearings and greater oil-felt capacity give longer motor life.
- Grooved bearings insure continuous oil return.
- Larger bearings reduce motor noise.
- Accurate metallurgical control of laminations insure uniform performance.
- Interchangeable mountings.
- Six standardized models, 1/500 to 1/45 HP.
- The correct motor for rotisseries, vending machines, office machines, chart drives, phonographs, slide projectors, heaters, refrigerators, hair dryers, deodorizers, 2" to 8" diameter fan blades, electronic equipment, etc. Write for complete specifications on your requirements.



SPECIFICATIONS

UNIVERSAL TYPE EA1 SKELETON MOTORS 115 VOLT 60 CYCLE

MODEL	HP @ 2,800 RPM	MAXIMUM TORQUE oz. in.	DIMENSIONS		
			A	B	C
EA1A	1/500	1.1	3/8"	1 53/64"	.1817
EA1B	1/350	1.4	1/2"	1 61/64"	.1817
EA1D	1/130	3.3	3/4"	2 3/16"	.1817
EA1E	1/90	4.5	1"	2 7/16"	.1817
EA1G	1/60	6.5	1 1/2"	2 15/16"	.250
EA1J	1/45	7.5	2"	3 7/16"	.250

12" leads on all models

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

CIRCLE 203 ON READER SERVICE CARD